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Volume 9 DECEMBER, 1935 Number 8

# JOURNAL OF PALEONTOLOGY

*A Publication of*
The Society of Economic Paleontologists and Mineralogists
*A Division of the American Association of Petroleum Geologists*
*and*
The Paleontological Society
*An Affiliate of the Geological Society of America*

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# JOURNAL of PALEONTOLOGY

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## ERRATA Vol. 9, No. 1

p. 34, col. 2, line 52, should read: "?*Lithostrotion* . . . Mansuy, 1912, etc."
p. 35, col. 1, line 6, should read: "Not *Lonsdaleia* . . . Mansuy, 1912, etc."
p. 35, col. 1, line 8, should read: "Not *Lonsdaleia* . . . Smith, 1925, etc."
p. 35, col. 1, line 11, should read: "Not *Lonsdaleia* . . . Ozawa, 1925, etc."

### No. 3

Plate 25. Change the number 24 to 25, 26 to 29, 27 to 26, 29 to 24, 25 to 27.
Legend as printed on page 249 will then read correctly.
p. 264: Cut shown as figure 2 should be figure 7 on page 268.
p. 268: Cut shown as figure 7 should be figure 2 on page 264.
Legends are correct as printed.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 8, PP. 623–628, PL. 76, DECEMBER, 1935

# OSTRACODES OF THE MORRISON FORMATION FROM THE BLACK HILLS, SOUTH DAKOTA

FRANCES HARPER and A. H. SUTTON
University of Illinois, Urbana, Illinois

ABSTRACT

Seven species (two new) and one new variety of ostracodes of the families Darwinellidae, Cypridae and Bairdiidae from the Morrison (Jurassic) formation of the northern Black Hills, South Dakota, are described. Two previously described species are shown to be male and female of the same species, and other changes in classification and nomenclature are made.

In June, 1933, the senior author collected material for microscopic study from the upper portion of the Morrison formation in the NW. $\frac{1}{4}$ of sec. 29, T. 6 N., R. 4 E., Lawrence County, South Dakota. The Morrison at the horizon of this collection is a rather hard, blocky, grayish-tan shale interlaminated with sandy layers and very thin, discontinuous lenses of sandy limestone about 1 cm. thick, composed almost exclusively of ostracode carapaces. Some ostracodes occur in the shale immediately above and below the limestone lenses.

The writers wish to express their thanks to Dr. J. J. Runner of the University of Iowa who directed the field collecting, and to Mr. H. L. Geis of the University of Chicago who examined some of the species and made helpful corrections and suggestions.

Types of new species are deposited with the Department of Geology and Geography at the University of Illinois.

## SYSTEMATIC DESCRIPTIONS

### Family DARWINELLIDAE Brady and Robertson, 1872

### Genus DARWINULA Brady and Robertson

*Darwinella* BRADY and ROBERTSON, *1872*, Annals and Mag. Nat. Hist. (4), vol. 9, p. 50; *1874*, Annals and Mag. Nat. Hist., vol. 13, p. 117; *1874*, Paleontogr. Soc., Mon. Post-Tertiary Entom., pp. 112–140.

*Darwinula* JONES, *1885*, Paleontogr. Soc., Jour., p. 346.

*Darwinula leguminella* JONES, *1886*, Geol. Mag., vol. 3, p. 147.

Carapace smooth, subcylindrical elongate, oblong-ovate, or subcuneate. Valves thin and smooth. Right valve larger than left and overlapping it along the entire margin. Length characteristically less than one millimeter.

#### DARWINULA DAKOTENSIS Harper and Sutton, n. sp.

Plate 76, figures 1, 2

General outline subreniform, ends rounded. Anterior extremity narrower, more elliptically curved, and more compressed than the posterior. Greatest length midway between the anterior and posterior ends. Greatest thickness in center of carapace. Hingement a straight line. Dorsal margin slightly concave in the central portion. Ventral margin convex. Right valve overlaps left along the entire margin. Surface smooth and shiny. Maximum length 0.5 mm.; maximum height 0.2 mm.; maximum thickness 0.1 mm.

*Remarks.*—The generic relationship of this species is distinct. Specifically it is closely allied with *D. leguminella* Jones, but is much more convex on the ventral margin and more concave on the dorsal.

The posterior end is broader and the anterior end less tapering than in *D. leguminella*.

## Family CYPRIDAE Zenker

### Genus METACYPRIS Brady

*Metacypris* BRADY, *1870*, Nature, March 10, p. 484.—BRADY and ROBERTSON, *1870*, Annals and Mag. Nat. Hist., (4), vol. 6, pp. 19, 20; *1872*, Annals and Mag. Nat. Hist., vol. 9, p. 51; *1874*, Paleontogr. Soc., Mon. Post-Tertiary Entom., pp. 112–116. —JONES, *1885*, Geol. Soc. London, Quart. Jour., p. 145; *1886*, Geol. Mag., vol. 3, p. 145; *1893*, Geol. Mag., vol. 10, p. 388.

Valves subrhomboidal or suboblong and very convex. Unequally tumid at both extremities. Anterior extremity narrower and more compressed. Posterior extremity more tumid. Dorsal and ventral margins nearly parallel. Ventral margin depressed along posterior half with valves swelling out beyond it. Hinge line distinct with thin flanges and narrow furrow. Right valve overlapping left. Surface pitted in lines.

#### METACYPRIS PAHASAPENSIS (Roth)

Plate 76, figures 3–11

*Jonesina pahasapensis* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 401, pl. 48, figs. 2*a–g*.

*Jonesina minnekahtensis* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 399, pl. 48, figs. 1*a–g*.

General outline suboblong. Ends rounded. Anterior end narrower and compressed. Posterior end more tumid, almost spherical in the female with well developed brood pouches. Greatest length midway between dorsal and ventral margins. Greatest height just posterior to the anterior cardinal angle. Greatest thickness just anterior to the posterior cardinal angle. Dorsal and ventral margins nearly parallel with the ventral margin depressed along the posterior half and both valves swelling out beyond it. Hinge line distinct with furrow and thin flange in the posterior half, and a posterior hinge tooth on the right valve. Two sulci on anterior half of valves. Posterior sulcus longer and extending nearly to the ventral margin. Anterior sulcus less pronounced. Left valve faintly overlaps right. Slight internal overlap of left valve by right on the ventral margin. Posterior cardinal angle acute. Anterior angle indistinct. Surface pitted with meshwork of polygonal pits on dorsal portion of carapace and with parallel lines of pits on ventral surface. A few scattered nodules on the female. Male distinctly nodose. Maximum length 1 mm.; maximum height 0.5 mm.; maximum thickness 0.7 mm.

*Remarks.*—Roth (6, p. 399) erroneously placed this species in the genus *Jonesina* and described the female as a separate species, *J. minnekahtensis*. According to Ulrich and Bassler (8, p. 324), who first described *Jonesina*, "The Leperditiidae and Beyrichiidae stand alone with no recognized affinities to post-Paleozoic ostracodes" (8, p. 279). In the reclassification of the Paleozoic Ostracoda in 1923, Ulrich and Bassler (9) raised Kloedenellidae from a subfamily of Beyrichiidae to family rank, but did not mention any occurrence later than the Carboniferous of the seven genera included.

The genus *Metacypris* has been reported from the Jurassic of England (3), from the Jurassic *Atlantosaurus* beds of Colorado (4), and from the Cretaceous Bear River formation of southwest Wyoming (5).

A comparison of Brady's description of *Metacypris* and Ulrich and Bassler's description of *Jonesina* shows that this Morrison species should be placed with *Metacypris*. Furthermore, Roth (6, p. 400) in his description of the Jurassic *Jonesina* says:

> If they are truly *Jonesina* then a reversal in orienting them is necessary. The more tumid end, here called anterior, will then be termed posterior. The valvular overlap will be reversed and the "backward" swing of the sulci can no longer be used as indicating the posterior but would indicate the anterior instead.

It seems to the writers that it is more logical to place this form in the genus

*Metacypris* than to reverse for this one species the accepted orientation of Ostracoda in which the retral swing of the sulci is used as a diagnostic feature. The authors are supported in this conclusion by Mr. H. L. Geis (2) who, after examining specimens of this genus said,

> I am entirely out of sympathy with Roth's orientation of "*Jonesina*." The thicker end should be posterior. Using this orientation, the right valve has a posterior hinge tooth, a feature I have not seen in *Jonesina*. Again, both valves seem to be grooved, causing, at least ventrally, an external overlap of the right by the left valve, and a very slight internal overlap of the left by the right. This is much more complex than the contact margins of *Jonesina* as I know it, in which genus the simple rounded margins of the left valve are simply overlapped by the right. These differences I consider to be of generic value.

The form described by Roth (6, p. 399) as *J. minnekahtensis* is undoubtedly the female of *M. pahasapensis*. If it were a distinct species one should expect to find young forms and molt stages in a representative collection. Such is not the case. It is possible to trace the development of *M. pahasapensis* stage by stage to the adult form, but no specimens smaller than the adult of the form described as *J. minnekahtensis* have been observed. It is possible, however, to trace the differentiation of the female by the increasing tumidity of the posterior half of the carapace all the way from *M. pahasapensis* to the form described as *J. minnekahtensis*. Only one fact, the distinctly nodose character of the male, raises any question as to the specific identity of these two forms. However both Brady (1) and Sars (7) have reported different surface ornamentation in the male and female carapaces of modern ostracodes, and there seems to be no reason why the same could not be true of fossil forms.

### Genus CYPRIDEA Bosquet

*Cypridea* BOSQUET, *1852*, Couronné. Acad. Roy. Belg., Mém., vol. 24, p. 47.—(Subgenus of *Cypris*) JONES, *1854*, Morris's Catalog Brit. Fossils, p. 104; *1856*, Mon. British Tertiary Entom., pp. 9, 10.—HUXLEY and ETHERIDGE, *1877*, Catalog Coll. Fossils Mus. Practical Geology, p. 88.—JONES, *1878*, Geol. Mag., Dec. 2, vol. 5, p. 107; *1893*, Geol. Mag., vol. 10, p. 386; *1885*, Geol. Soc. London, Quart. Jour., vol. 41, p. 336.

*Pseudocypridina* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 404.

General outline subtriangular to obovate or ovate-oblong. Greatest height about one-third of the distance from the anterior to posterior extremity. Anterior extremity somewhat compressed and notched behind a beak-like projection at the antero-ventral angle. Some specimens have only a slight indentation below and behind a thickening of the antero-ventral angle, which may be traceable only by a curvature of the edge inside. Hinge line straight along the middle third of the dorsal edge and oblique to the main axis of the carapace. Left valve overlaps the right with a ridge and groove on the dorsal and ventral margins.

#### CYPRIDEA PIEDMONTI (Roth)

Plate 76, figures 12–15

*Pseudocypridina* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 404.

General outline sub-hemicircular. Greatest length between the anterior termination of hingement and the ventral edge. Greatest height one-third of the distance from the anterior to posterior extremity. Greatest width in the plane of greatest length and slightly posterior to the central part of the carapace. Anterior extremity designated by a beak-like projection. The genus *Cypridea* is characteristically notched or slightly indented in front of this beak, but in the species examined only one immature and broken single valve was observed, so it is impossible to state definitely the existence or non-existence of this notch or indentation. Hinge line straight and oblique to the main axis of the carapace and marked on the surface by a V-shaped trough. Left valve over-

laps right on dorsal and ventral edges. Ridge of right valve fits into a groove of the left on the dorsal margin. Dorsal margin broadly arcuate except on the hinge line where it is depressed. Ventral margin inclined to the hinge line. Anterior cardinal angle less obtuse than posterior. Surface covered by a meshwork of polygonal pits. Maximum length 1.1 mm.; maximum height 0.9 mm.; maximum thickness 0.5 mm.

*Remarks.*—Roth erects a new genus, *Pseudocypridina*, for this species on the basis of the absence of a notch behind the antero-ventral beak. Because he did not demonstrate the absence of a notch in either the discussion or illustration of the form, and since the only specimen observed by the authors showing the interior of the valve was a broken and immature specimen, they are inclined to think it wiser to leave this species in the genus *Cypridea* until there is enough evidence to warrant the establishment of a new genus. Otherwise Roth's description of the new genus checks in all details, even to the surface markings, with the description of *Cypridea*.

The antero-ventral beak is quite rudimentary in the young of this species. The hemicircular outline of the carapace is also lacking in the young, and only by carefully tracing the development of the individuals is it possible to establish the specific identity of the young and mature forms.

### Genus PARACYPRIS Sars, 1865

*Paracypris* SARS, *1921*, Account of the Crustacea of Norway, vol. 9, p. 69.

Sars established this genus on living forms and gave little description of the carapace, beyond the fact that it is elongate, compressed and narrowly produced behind. The right valve overlaps the left along the free margin.

#### PARACYPRIS SIMPLUS Roth

Plate 76, figure 18

*Paracypris simplus* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 403, pl. 48, figs. *3a–d*.

General outline subellipsoidal. Greatest length midway between dorsal and ventral margins. Greatest height two-thirds of the distance from anterior to posterior extremity. Greatest thickness slightly anterior to the plane of greatest height and in the plane of greatest length. Right valve overlaps left along ventral margin. Posterior end bluntly ovate. Surface of valves smooth. Maximum length 1.1 mm.; maximum height 0.5 mm.; maximum thickness 0.1 mm.

*Remarks.*—Sars described this genus from the crustaceans living at present along the south and west coast of Norway. This is the only species that has been reported in fossil form. Roth in his description of *P. simplus* did not differentiate between generic and specific characters and Sars made little use of the carapace in his description, consequently

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EXPLANATION OF PLATE 76

FIGS. 1, 2—*Darwinula dakotensis* Harper and Sutton, n. sp. Holotype, ×26. 1, Left valve; 2, right valve. (p. 623)

3–11—*Metacypris pahasapensis* (Roth). All figures ×26 except 11 which is ×20. 3, 4, Dorsal and ventral margins of male; 5, left valve of male; 6, 7, left and right valves of female; 8, 9, ventral and dorsal margins of female; 10, left valve of young; 11, interior of right valve of male. (p. 624)

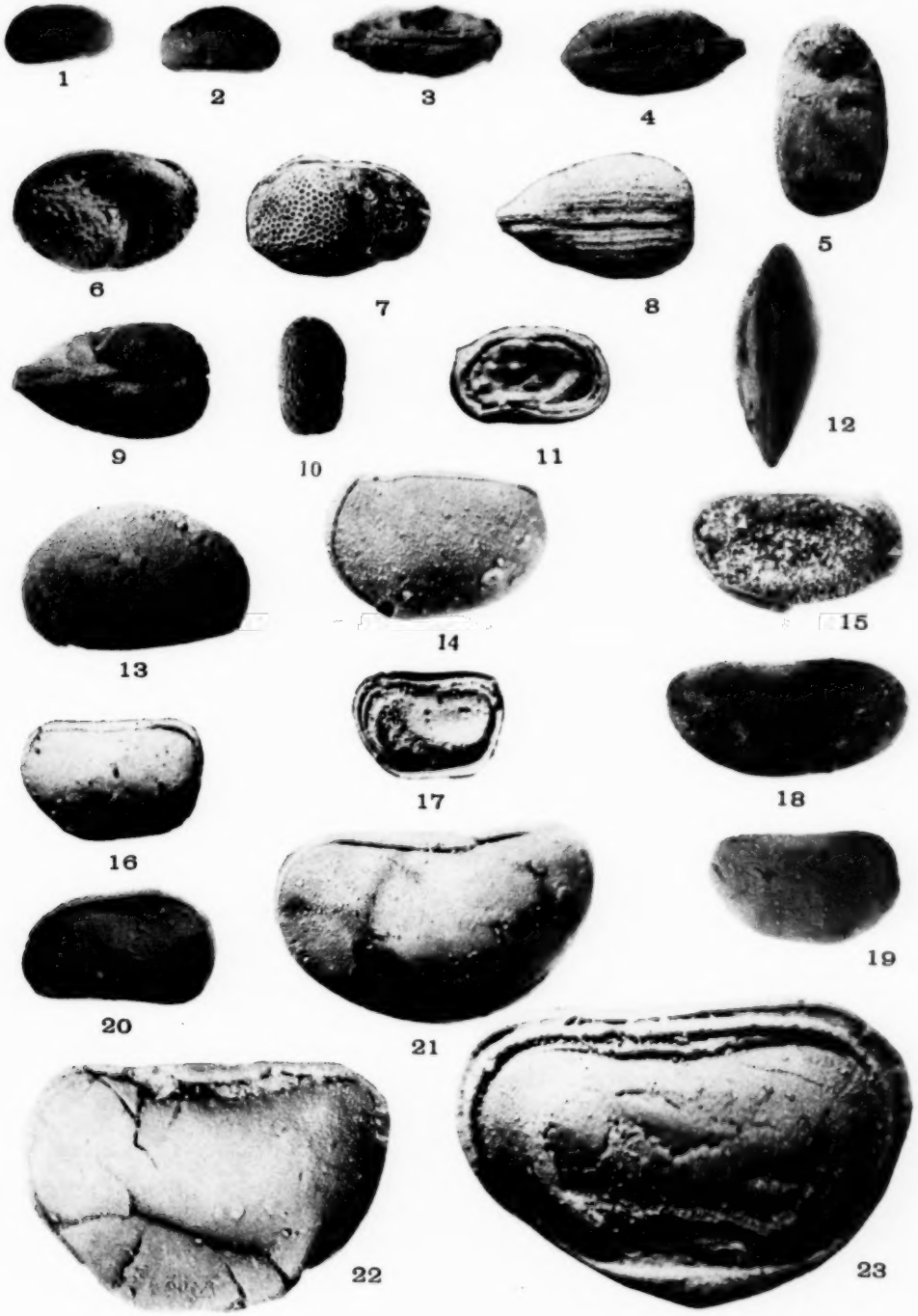
12–15—*Cypridea piedmonti* (Roth), ×26. 12, Dorsal margin; 13, 14, left and right valves; 15, interior of right valve of young, imperfect specimen. (p. 625)

16, 17—*Bairdiocypris trapezoidalis* Roth, ×20. 16, Right valve; 17, interior of left valve. (p. 628)

18—*Paracypris simplus* Roth, ×26. Right valve. (p. 626)

19, 20—*Bairdiocypris celtiformis* Harper and Sutton, n. sp. Holotype, ×26. 19, Left valve; 20, right valve. (p. 627)

21–23—*Bairdiocypris morrisonensis* var. *equalis* Harper and Sutton, n. var., ×26. 21, Right valve; 22, crushed and immature right valve; 23, right valve showing internal mold of left. (p. 627)




Harper and Sutton, Jurassic Ostracoda

the relationship of this shell to *Paracypris* is rather vague.

## Family BAIRDIIDAE

### Genus BYTHOCYPRIS Brady, 1865

Shell more or less compressed, of oval or reniform shape. Edge unarmed. This genus was described from modern ostracodes and little mention of the characters of the carapace was made.

### Sub-genus BAIRDIOCYPRIS Kegel, 1931

General outline subquadrate to subreniform. Ventral margin gently concave. Semi-false keel parallels the middle portion of the ventral margin and a ridge parallels the dorsal margin of the left valve. Left valve overlaps right on hinge line and along the middle portion of the dorsal margin.

#### BAIRDIOCYPRIS MORRISONENSIS Roth

*Bairdiocypris morrisonensis* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 401, pl. 48, figs. 4*a–c*.

General outline subreniform. Greatest length two-thirds the distance from dorsal to ventra margin. Greatest height posterior to central portion of carapace. Greatest thickness in center of carapace. Anterior end slightly compressed and more sharply arcuate than posterior, which is quite blunt. Hinge line simple and straight, extending the length of the umbo of left valve. Dorsal margin broadly arcuate. Ventral margin gently concave, extending almost the entire length of the carapace. Overlap of right valve by left not very prominent except on the hinge line and along the middle portion of the dorsal margin. A semi-false keel paralleling the dorsal margin of the left valve is the only surface ornament.

#### BAIRDIOCYPRIS MORRISONENSIS var. EQUALIS Harper and Sutton, n. var.

Plate 76, figures 21–23

Carapace similar to *B. morrisonensis* but without the sharply arcuate anterior and blunt posterior extremities which characterize *B. morrisonensis*. The posterior extremity of *equalis* is only slightly more arcuate than the anterior and practically equidistant from the umbonal region, whereas in *B. morrisonensis* the anterior portion of the carapace is longer than the posterior. Maximum length 2.5 mm.; maximum height 1.8 mm.; maximum thickness 1 mm.

*Remarks.*—This form clearly belongs in the sub-genus *Bairdiocypris* and the species *morrisonensis*. Since Roth does not mention variations in *B. morrisonensis*, this form is considered a new variety of that species.

#### BAIRDIOCYPRIS CELTIFORMIS Harper and Sutton, n. sp.

Plate 76, figures 19, 20

Carapace high and compressed. Anterior extremity more broadly arcuate than the posterior and flattened into a pronounced cuneate shape. Valves subequal. Greatest length midway between the dorsal and ventral margins. Greatest height slightly anterior to the anterior cardinal angle. Greatest thickness at center of carapace. Dorsal margin straight or concave and slightly inclined to the posterior. Overlap of right valve on left quite pronounced on the dorsal and ventral edges, but less so on the anterior extremity. Ventral margin gently convex. Ridge or keel along ventral margin of left valve. Surface of valves smooth. Maximum length 1 mm.; maximum height 0.75 mm.; maximum thickness 0.2 mm.

*Remarks.*—The false keel along the ventral margin of the left valve places this species in the genus *Bairdiocypris*. The species possesses some characters suggestive of the young of *B. trapezoidalis*, but the majority of adult specimens are considerably larger than the smallest adult specimens of *B. trapezoidalis*, which eliminates the possibility of *B. celtiformis* being the young of the latter species. The young of *B. celtiformis* are quite deceptive in appear-

ance since the dorsal and ventral ridges are entirely lacking in the smallest specimens.

BAIRDIOCYPRIS TRAPEZOIDALIS Roth

Plate 76, figures 16, 17

*Bairdiocypris trapezoidalis* ROTH, *1933*, Jour. Paleontology, vol. 7, no. 4, p. 402, pl. 48, figs. *6a–d*.

General outline subtrapezoidal. Posterior cardinal angle near a right angle. Anterior cardinal angle more acute. Left valve overlaps the right very prominently along the dorsal and ventral margins, less on the posterior margin. Right valve overlaps left slightly on the anterior extremity. Hinge line straight and simple. Surface smooth. Maximum length 1.2 mm., maximum height 1.1 mm.; maximum thickness 0.6 mm.

*Remarks.*—This form is identical with the one reported by Roth from the Morrison of South Dakota. Roth probably collected his material from Lawrence County, sec. 28, T. 6 N., R. 4 E., instead of T. 4 N., R. 6 E., which is in Meade County and mapped as Carboniferous. The former locality is within five miles of the point where our material was collected.

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JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 8, PP. 629–646, PLS. 77–78, DECEMBER, 1935

# THE OSTRACODE FAUNA OF THE BIRDSONG SHALE, HELDERBERG, OF WESTERN TENNESSEE

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ABSTRACT

Forty-eight species of ostracodes are listed from the Birdsong shale of western Tennessee Three new genera and twenty-four new species are described. The new genera include *Placentella* in the Primitiidae, and *Eucraterellina* and *Rothella* in the Thlipsuridae. The new species belong to the following genera: *Aparchites, Paraparchites, Haploprimitia, Bollia, Placentella, Aechmina, Paraechmina, Amphissites, Kirkbyella, Strepula, Eucraterellina, Thlipsurella, Octonaria, Rothella, Bythocypris, Pontocypris,* and *Microcheilinella.*

During the spring of 1934, Prof. L. C. Glenn and I made collections from the Birdsong shale in Decatur, Henry, and Benton counties, Tennessee. The weathered shale gathered with the collections of macrofossils yielded abundant ostracodes. All of the ostracodes here described were collected from the Birdsong shale. This formation was named from the exposures along Birdsong Creek and its tributaries in Benton County. Collections were made from the following five localities:

*Localities*

1. At the steel bridge over Big Sandy River 4½ miles above the mouth of the river and 1½ miles east of Antioch Church, Henry County. The fossils were collected from the soft, bluish, calcareous shale exposed in the river bank at the east end of the bridge.

2. Just north of Perryville, Decatur County. Collections were made from the small exposures of bluish, calcareous shale under the western end of the State Highway bridge over the Tennessee River.

3. About 4½ miles north of Holladay, Benton County, near the home of Mr. Will Love. Collections were made from several glades on Mr. Love's property.

4. About 2½ miles north-northeast of Jeannette, Decatur County. The fossils were collected from several glades on the Allen Conrad place.

5. Two and one-half miles northeast of Parsons, Decatur County. The Birdsong shale is well exposed on the north side of the road where it crosses a small glade.

The types are deposited at Vanderbilt University.

I wish to express my gratitude and acknowledge my indebtedness to L. C. Glenn and H. L. Geis for their valuable suggestions and helpful criticisms. I am indebted also to R. S. Bassler, Robert Roth, Frank M. Swartz, and Betty Kellett Nadeau for suggestions on the taxonomic position of several of the new species.

## AGE AND CORRELATION OF THE BIRDSONG SHALE

The stratigraphic horizon of this shale is shown in the section on page 630 taken from Dunbar.

The description of the Birdsong shale given by Dunbar (1, p. 55) is as follows:

The Birdsong formation begins with a few feet (8 to 10) of heavy-bedded, rather pure, coarsely crystalline limestone. Above this it passes into interbedded bluish shale and thin bands of crystalline limestone and then into

softer, calcareous, blue shale, constituting the upper half to three-fourths of the formation. Harder calcareous laminae and thin bands or lentils of limestone occur throughout the shale. When fresh the latter is partly indurated by its large percentage of calcium carbonate, but it weathers into bluish clay and a rubble of small limy fragments forming barren hillside slopes or "glades."

In his study of the macrofauna Dunbar recognized three major fau-

*Classification of Lower Devonian Rocks in Western Tennessee*

| | | |
|---|---|---|
| Lower Devonian | Oriskany | Harriman chert |
| | | Quall limestone |
| | Helderberg (Linden) | Decaturville chert |
| | | BIRDSONG SHALE |
| | | Olive Hill formation |
| | | Rockhouse shale |

nal zones in the remarkably fossiliferous Birdsong shale. These are, in order from top downward:

(1) Trilobite zone; 22 feet in thickness; characterized by species of *Dalmanites* and *Phacops*.
(2) Bryozoa zone; 5 to 6 feet in thickness; crowded with ramose, massive, and incrusting forms of Bryozoa.
(3) Brachiopod zone; 35 to 40 feet in thickness.

The striking resemblance of the fauna of the Birdsong shale to that of the New Scotland formation of New York was recognized by James Hall as early as 1859. Of the 99 species listed by Dunbar, 60 also occur in the New Scotland of New York.

Among these are almost all of the diagnostic species, as *Orthostrophia strophomenoides, Dalmanella subcarinata, D. perelegans, Bilobites varicus, Leptostrophia beckii, Leptaenisca adnascens, L. concava, Scenidium insigne, Anastrophia verneuili, Camarotoechia bivalveata, Eospirifer macropleura, Delthyris perlamellosa, Spirifer cycloptera, Cyrtina dalmani, Phacops logani*, etc. Considering the distance which separates Tennessee and New York, the correspondence in these forms is remarkable, and clearly indicates not only equivalence in age but a rather direct communicating seaway.

On the other hand, there are a number of trilobites and crinoids in New York which did not get into the Mississippi embayment, while certain important elements in the Birdsong fauna do not occur at this time in the Appalachian trough. Such conspicuous examples are the various species of *Scyphocrinus* and the associated *Camarocrinus, Edriocrinus adnascens, E. pyramidatus, Rensselaerina medioplicata, Eatonia tennesseensis, Gypidula multicostata*, and *Meristella atoka*. These forms are believed to be of Gulf of Mexico derivation. The Scyphocrini with *Camarocrinus* in particular, were sequestered somewhere in the south from late Middle Silurian time (Decatur) almost to the end of the Helderbergian, appearing in great abundance in both Tennessee and Oklahoma, whereas they only succeeded in reaching the Appalachian trough for a very brief period, being known very rarely in the Manlius (?) of New York and in a zone near the middle of the Keyser of Maryland. This circumstance is believed to indicate that the Helderbergian seas of Oklahoma and Tennessee represent an embayment from the south, especially since *Camarocrinus* in Europe is limited to the southern or Bohemian province. Nevertheless, a communicating seaway most probably existed during New Scotland time between this Gulf embayment and the Appalachian trough. Its most likely position seems to have been across medial Kentucky and West Virginia, since this was the location, during much of Paleozoic time, of a sag or trough in the Cincinnati axis, and since in the Appalachian trough the Helderbergian formations thin out farther southward.

The Haragan shale of Oklahoma represents a western arm of this epiric sea. Its fauna contains thirty-six species in common with that of the Birdsong shale, and the intimate relation of the faunas is further shown by the

presence in both of species indigenous to this southern embayment, such as *Rensselaerina medioplicata* and *Meristella atoka*, and by the great abundance of *Camarocrinus*. The fauna of the Haragan shale, however, is characterized by the absence of *Eospirifer macropleura* and *Leptostrophia beckii* and by a greater abundance of *Phacops logani*, *Meristella atoka*, and *Orthostrophia strophomenoides*. In these respects it most nearly agrees with the upper or trilobite zone of the Birdsong. . . . The Haragan shale . . . appears to be equivalent to the highest portion of the Birdsong (1, pp. 62, 63).

## ANALYSIS OF THE OSTRACODE FAUNA

The range and distribution of the species of ostracodes found in the Birdsong shale may best be summarized in the following faunal list:

*Ostracode Fauna of the Birdsong Shale*[1]

| | |
|---|---|
| **LEPERDITELLIDAE** | |
| *Aparchites punctinellus* Wilson, n. sp. | r |
| *Paraparchites triangulatus* Wilson, n. sp. | r |
| **PRIMITIIDAE** | |
| *Haploprimitia holladayi* Wilson, n. sp. | r |
| *Ulrichia conradi* Jones[a] | r |
| *Bollia ungula* Jones[b] | r |
| *Bollia haragenensis* Roth* | a |
| *Bollia magnoarenaria* Wilson, n. sp. | c |
| *Bollia wurmi* Wilson, n. sp. | r |
| *Bollia jugaloidea* Wilson, n. sp. | c |
| *Placentella delicata* Wilson, n. sp. | r |
| *Placentella elliptica* Wilson, n. sp. | r |
| *Aechmina cuspidata* Jones and Holl[c,g] | a |
| *Aechmina simplex* Ulrich and Bassler[d] | (?) |
| *Aechmina spicaferella* Wilson, n. sp. | a |
| *Paraechmina lacia* Wilson, n. sp. | r |
| **BEYRICHIIDAE** | |
| *Ctenobolbina granosa* Ulrich*[e] | r |
| **KIRKBYIDAE** | |
| *Amphissites retiferus* Roth* | a |
| *Amphissites primaevus* Roth* | r |
| *Amphissites planus* Wilson, n. sp. | c |
| *Kirkbyella perplexa* Wilson, n. sp. | a |
| *Kirkbyella magnopunctata* Wilson, n. sp. | r |
| *Strepula bentoni* Wilson, n. sp. | c |
| **THLIPSURIDAE** | |
| *Thlipsura furca* Roth* | a |
| *Eucraterellina randolphi* Wilson, n. sp. | a |
| *Eucraterellina moorei* Roth* | c |
| *Thlipsurella fossata* (Roth)* | r |
| *Thlipsurella curvistriata* (Roth)* | r |
| *Thlipsurella perryvillia* Wilson, n. sp. | r |
| *Octonaria glenni* Wilson, n. sp. | a |
| *Rothella recta* (Roth)* | a |
| *Rothella obliqua* (Roth)* | c |
| *Rothella obtusa* Wilson, n. sp. | r |
| *Rothella birdsongia* Wilson, n. sp. | r |
| *Phanassymetria triserrata* Roth* | a |
| *Phanassymetria quadrupla* Roth* | a |
| **BAIRDIIDAE** | |
| *Bythocypris indianensis* Ulrich[f] | c |
| *Bythocypris simplex* Roth* | c |
| *Bythocypris devonica* Ulrich[f] | r |
| *Bythocypris transversa* Roth* | r |
| *Bythocypris symmetrica* Jones[c] | r |
| *Bythocypris hollii* Jones[c] | r |
| *Bythocypris geisi* Wilson, n. sp. | a |
| *Bythocypris kershavii* Wilson, n. sp. | r |
| *Bythocypris parsonia* Wilson, n. sp. | r |
| *Pontocypris delicata* Wilson, n. sp. | c |
| **CYPRIDAE** | |
| *Condracypris simplex* Roth* | r |
| **CYTHERELLIDAE** | |
| *Pachydomella longula* Ulrich and Bassler[h] | r |
| *Microcheilinella decaturi* Wilson, n. sp. | r |

[1] Explanation: a=abundant, c=common, r=rare, *=represented in the Haragan marl of southern Oklahoma.

[a] Occurs in Middle Devonian of Ontario, Kentucky, Michigan, etc.

[b] Occurs in Lower and Middle Devonian at various places.

[c] Occurs in Wenlock beds of England.

[d] Occurs in Clinton beds of Pennsylvania.

[e] Occurs in Helderberg beds of New York.

[f] Occurs in Onondaga limestone of Kentucky.

[g] Occurs in Helderberg beds of West Virginia.

[h] Occurs in Helderberg beds of Maryland.

Of the 48 species of ostracodes occurring in the Birdsong shale, there are 15, as noted in the preceding table, which are also found in the Haragan marl. These include many

types that are abundant or common in the Birdsong. This very striking faunal similarity supplements the evidence presented by the study of the megafauna and definitely demonstrates the close relationship between these two formations.

Whereas only two Haragan species, *Octonaria inaequalis* (reported from the Keyser of Maryland) and *Ctenbolbina granosa* (reported from the New Scotland of New York), occur in the Devonian of the Appalachian region, the Birdsong shale contains species found also at various other localities (see table).

The correlation of the New Scotland of New York, the Haragan of Oklahoma, and the Birdsong of Tennessee on the basis of the ostracode fauna corresponds closely with the correlation based on the megafauna.

## ORIENTATION OF OSTRACODE SHELLS

The problem of the orientation of the carapaces of ostracodes has become one of vital significance. I have accepted as most logical the conclusions of Geis (2), who places the thickened end of the carapace at the posterior. Wherever possible I have followed this rule but in the case of genera that do not have one end thicker than the other, the commonly accepted orientation is tentatively adopted. In order that the reader may quickly note the orientation of each of the genera mentioned, the following summary is given.

*Summary of orientations used in this paper*

| | |
|---|---|
| *Aparchites* | Accepted orientation |
| *Paraparchites* | Accepted orientation |
| *Haploprimitia* | Accepted orientation |
| *Bollia* | Accepted orientation |
| *Placentella* | Accepted orientation (like *Jonesites*) |
| *Aechmina* | Thick, spine-bearing end considered posterior |
| *Paraechmina* | Accepted orientation |
| *Amphissites* | "Backward" swing considered anterior (after Geis) |

EXPLANATION OF PLATE 77

FIGS. 1*a–c*—*Aparchites punctinellus* Wilson, n. sp., ×25. *a*, Left valve of holotype. *b*, Ventral aspect of holotype. *c*, Left valve. Loc. 1. (p. 633)

2*a–d*—*Paraparchites triangulatus* Wilson, n. sp., ×40. *a*, Left valve. *b*, Dorsal aspect of holotype. *c*, Right valve. *d*, Ventral aspect of holotype. Loc. 2. (p. 633)

3*a*, *b*—*Haploprimitia holladayi* Wilson, n. sp. ×40. *a*, Left valve. *b*, Left valve. Syntypes. Loc. 3. (p. 634)

4*a–c*—*Bollia magnoarenaria* Wilson, n. sp., ×25. *a*, Left valve. *b*, Right valve. *c*, Left valve. Syntypes. Loc. 1. (p. 634)

5*a–d*—*Bollia wurmi* Wilson, n. sp., ×25. *a*, Left valve. *b*, Right valve. *c*, Dorsal aspect. *d*, Ventral aspect. Holotype. Loc. 4. (p. 635)

6*a*, *b*—*Bollia jugaloidea* Wilson, n. sp., ×25. *a*, Left valve. *b*, Left valve. Syntypes. Loc. 3. (p. 635)

7*a*, *b*—*Placentella delicata* Wilson, n. sp. *a*, Left valve, ×35. *b*, Right valve, ×40. Syntypes. Loc. 1. (p. 636)

8*a*, *b*—*Placentella elliptica* Wilson, n. sp., ×40. *a*, Left valve. *b*, Right valve. Syntypes. Loc. 1. (p. 637)

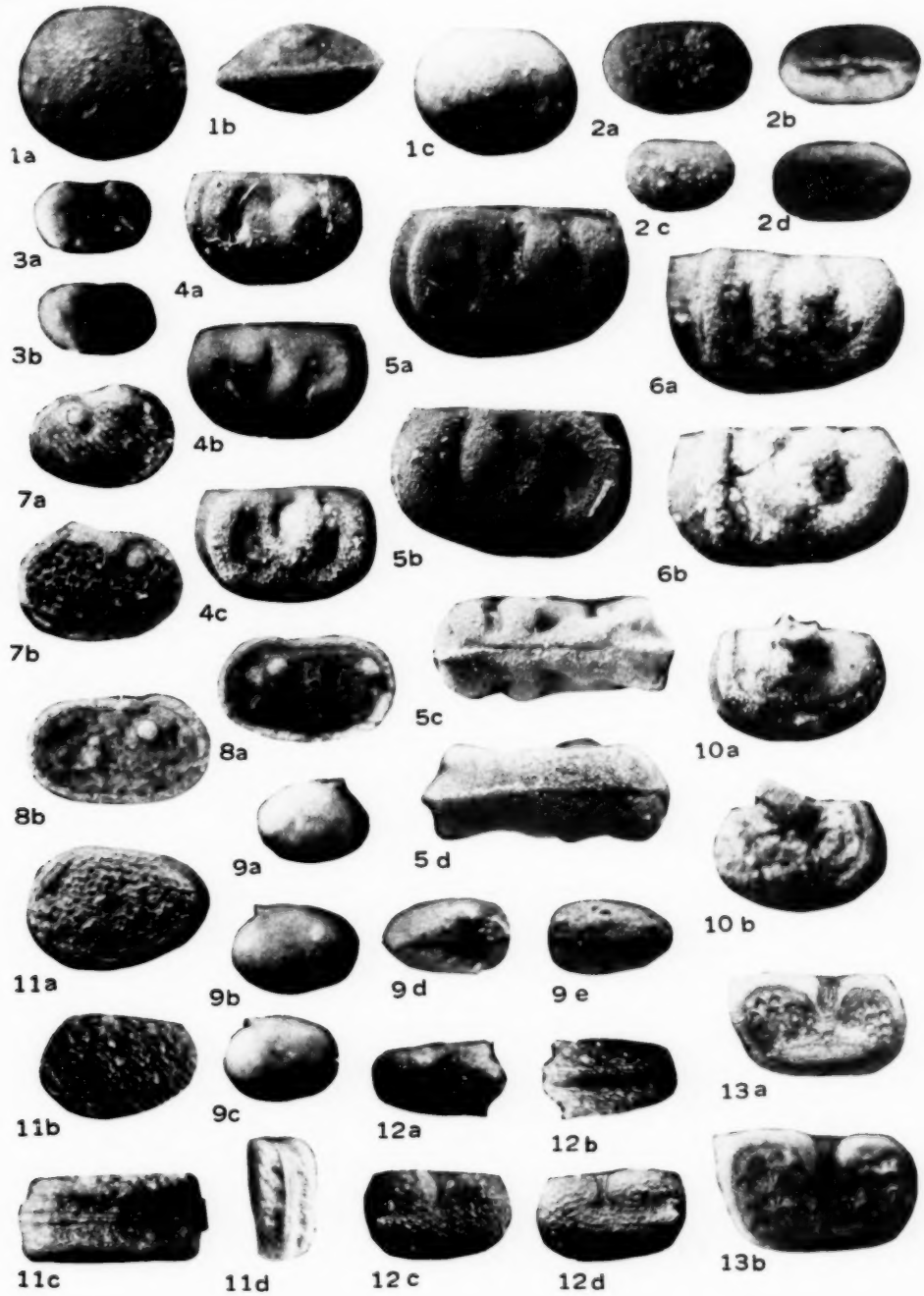
9*a–e*—*Aechmina spicaferella* Wilson, n. sp., ×40. *a*, Left valve. *b*, Right valve. *c*, Right valve. *d*, Dorsal aspect of holotype. *e*, Ventral aspect of holotype. Loc. 1. (p. 637)

10*a*, *b*—*Paraechmina lacia* Wilson, n. sp., ×25. *a*, Right valve. *b*, Left valve. Syntypes. Loc. 1. (p. 637)

11*a–d*—*Amphissites planus* Wilson, n. sp., ×25. *a*, Left valve. *b*, Left valve. *c*, Ventral aspect. *d*, Anterior extremity. Loc. 2. (p. 638)

12*a–d*—*Kirkbyella perplexa* Wilson, n. sp., ×25. *a*, Dorsal aspect of holotype. *b*, Ventral aspect of holotype. *c*, Right valve. *d*, Left valve. Loc. 5. (p. 639)

13*a*, *b*—*Kirkbyella magnopunctata* Wilson, n. sp. *a*, Right valve, ×35. *b*, Right valve, ×40. Loc. 1. (p. 639)




Wilson, Devonian Ostracoda

| | | | |
|---|---|---|---|
| *Kirkbyella* | Thick end considered posterior | *Rothella* | Thick end considered posterior |
| *Strepula* | Accepted orientation | *Bythocypris* | Accepted orientation |
| *Eucraterellina* | Thick end containing crater considered posterior | *Pontocypris* | Thick end considered posterior |
| *Thlipsurella* | Thick and more acute end considered posterior | *Microcheilinella* | Thick end considered posterior (after Geis) |
| *Octonaria* | Accepted orientation | | |

## SYSTEMATIC DESCRIPTIONS

### Family LEPERDITELLIDAE Ulrich and Bassler

### Genus APARCHITES Jones, 1889

APARCHITES PUNCTINELLUS Wilson, n. sp.

Plate 77, figures 1*a–c*

Carapace subcircular; maximum length midway between dorsal and ventral margins; maximum height and breadth are both midway between anterior and posterior extremities; dorsal margin straight; dorsal aspect shows both valves tapering from the line of greatest breadth at the center of the valves to both extremities; ventral margin slightly thickened and rounded, being more broadly rounded at the posterior extremity; anterior and posterior extremities are both symmetrical curves with the anterior and posterior cardinal angles about equal; carapace equivalved. The surface is marked by small, shallow punctae, whose diameters average about half the distance between two adjacent punctae.

Measurements of holotype: length, 0.92 mm.; height, 0.82 mm.; breadth, 0.51 mm.

*Remarks.*—The species resembles *A. simplex* Jones, but differs in possessing punctae, a more pronounced hinge-line, and smaller size. *A. punctinellus* differs from *Primitia? lenticularis* Jones and Holl in possessing punctae, a more pronounced hinge-line, a more uniformly circular outline, a more centrally located maximum breadth, and smaller size. The chief difference between *A. variolatus* Ulrich and Bassler (and *A. variolatus huntonensis* Roth) and *A. punctinellus* is the contrast of large, deep pits in the former with the small, shallow punctae of the latter, which are so faint that on some well preserved specimens they are not discernible. *A. punctinellus* also differs from *A. variolatus* in possessing a more pronounced hinge line and in being almost twice as large as the measurements given by Ulrich and Bassler.

*Occurrence.*—Birdsong shale, locality 1.

### Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES TRIANGULATUS Wilson, n. sp.

Plate 77, figures 2*a–d*

Carapace small and subelliptical; maximum length approximately midway between dorsal and ventral margins; maximum height in posterior third of carapace; dorsal margin straight; dorsal aspect shows channeled hinge-line; ventral margin curves smoothly from ventral-anterior corner backward to join the backward swing of the ventral-posterior corner; ventral aspect shows a double furrow between the anterior and posterior extremities; anterior extremity roundly convex, with abrupt dorsal swing and more gentle ventral swing from the most anterior point; posterior extremity has a backward swing; posterior extremity aspect shows an almost equilateral triangle with slightly rounded sides. Right valve slightly larger than left valve. Surface smooth.

Measurements of holotype: length, 0.50 mm.; height, 0.30 mm.; breadth, 0.28 mm.

*Occurrence.*—Birdsong shale, locality 2.

## Family PRIMITIIDAE Ulrich and Bassler

### Genus HAPLOPRIMITIA Ulrich and Bassler, 1923

#### HAPLOPRIMITIA HOLLADAYI Wilson, n. sp.

Plate 77, figures 3*a*, *b*

Carapace small and subelliptical; maximum length approximately midway between dorsal and ventral margins; dorsal margin straight, but with a small, local re-entrant above the sulcus; ventral margin slightly convex in middle portion and curves smoothly upward to join the anterior and posterior extremities; anterior extremity roundly convex; posterior extremity roundly convex with a slight suggestion of increased height of valve and of a backward swing. Equivalved. Surface smooth except for a deep, straight sulcus that leaves the dorsal margin slightly posterior of the center and extends downward half the height of the valve. Sulcus in some specimens increases in width downward.

Average measurements of syntypes: length, 0.40 mm.; height, 0.24 mm.

*Occurrence.*—Birdsong shale, locality 3.

### Genus ULRICHIA Jones, 1890

#### ULRICHIA CONRADI Jones

*Ulrichia conradi* JONES, *1890*, Geol. Soc. London, Quart. Jour., vol. 46, p. 544, text fig. 2; *1891*, Canada Geol. Survey, Contr. Can. Micropaleont., pt. 3, p. 95, pl. 11, fig. 13.—KINDLE, *1912*, U. S. Geol. Survey, Bull. 508, p. 115, pl. 9, fig. 12.—ULRICH and BASSLER, *1913*, Maryland Geol. Survey, Lower Devonian, p. 518, pl. 95, fig. 11.—WARTHIN, *1934*, Univ. Mich., Mus. Paleontology, Contr. 4, no. 12, p. 213, pl. 1, fig. 10.

This species is represented by three good specimens in the Birdsong collection from locality 1. The nodes on the Birdsong specimens are slightly elongated while on the previously described and figured specimens the nodes are more round.

### Genus BOLLIA Jones and Holl, 1886

#### BOLLIA UNGULA Jones

*Bollia ungula* JONES, *1889*, Am. Geologist, vol. 4, p. 338, figs. 10–13.—ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 188, pl. 14, figs. 6*a*, *b*.—KINDLE, *1912*, U. S. Geol. Survey, Bull. 508, p. 113, pl. 9, figs. 9, 10.—ULRICH and BASSLER, *1913*, Maryland Geol. Survey, Lower Devonian, p. 528, pl. 96, figs. 20–22; Maryland Geol. Survey, Middle and Upper Devonian, p. 336, pl. 44, figs. 7, 8.

Several specimens belonging to this species occur in the Birdsong collections from localities 2 and 3.

#### BOLLIA HARAGANENSIS Roth

*Bollia haraganensis* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 334, pl. 35, figs. 2*a–d*.

This is one of the most abundant species found in the Birdsong shale, being found at all five localities.

#### BOLLIA MAGNOARENARIA Wilson, n. sp.

Plate 77, figures 4*a–c*

Carapace subrectangular; maximum length midway between dorsal and ventral margins; maximum height about one-third of shell length from the anterior; dorsal margin straight; ventral margin slightly convex, and rounds smoothly into both extremities; anterior extremity curves broadly from the hinge line to the ventral margin; posterior extremity forms a slightly obtuse angle with the hinge line, swings backward for a short distance before turning to swing into the ventral margin. Equivalved. Free margins are bordered by a wide, rounded ridge that extends the entire distance from the dorsal-anterior angle to the dorsal-posterior extremity. There is a narrow platform outside this marginal ridge on the anterior extremity. Within the ridge bordering the free margins is a loop whose dorsal-posterior end is bulbous. The marginal ridge and the loop are joined at the ventral curve, or bottom, of the loop, forming an isolated depression posterior to the anterior portion of the marginal ridge.

Average measurements of syntypes: length, 1.00 mm.; height, 0.51 mm.

*Remarks.*—*B. haraganensis* Roth is the most closely related species to *B. magnoarenaria*, but the latter differs in having the marginal ridge connected with

the loop and in having the anterior ends of the marginal ridge and the loop connected, leaving an isolated depression in the anterior portion of the valve. These connecting ridges cause the loop to lose part of the distinctness that is diagnostic of *Bollia*. For this reason *B. magnoarenaria* might not be a true *Bollia*, but certainly *B. haraganensis* and *B. magnoarenaria* belong to the same genus.

*Occurrence.*—Birdsong shale, localities 1 and 4.

BOLLIA WURMI Wilson, n. sp.

Plate 77, figures 5*a–d*

Carapace subrectangular; maximum length midway between dorsal and ventral margins; maximum height about one-third of shell length from the anterior; dorsal margin straight; ventral margin slightly convex, rounding smoothly into both extremities; anterior extremity leaves dorsal margin with an obtuse angle and curves broadly before meeting ventral margin; posterior extremity leaves dorsal margin with a very slight obtuse angle, curving to meet the ventral margin with a sharper swing than the anterior extremity. Equivalved. Free margin bordered by a broad ridge. A narrow platform occurs outside the submarginal ridge on the anterior extremity. Within this ridge is a loop, the posterior portion of which is bulbous. The anterior portion of the loop is depressed below the level of the marginal ridge and the bulbous posterior portion of the loop. The marginal ridge and the loop meet at the bottom of the loop in a broad, swollen area. The dorsal-anterior end of the marginal ridge is connected with the dorsal-anterior end of the loop, forming an isolated depression posterior to the anterior portion of the marginal ridge. Surface of the marginal ridge and the loop is pitted with small, shallow pits, the inter-pit distance being several times the diameter of the pits.

Measurements of holotype: length, 1.30 mm.; height, 0.80 mm.; breadth, 0.52 mm.

*Remarks.*—This species differs from *B. magnoarenaria* by having a slightly different outline; a pitted surface; a broader connection between the ventral part of the marginal ridge and the bottom of the loop; and in having the anterior portion of the loop depressed. These differences, however, are only of specific value for *B. wurmi* and *B. magnoarenaria* undoubtedly belong to the same genus. The former is more unlike a typical *Bollia* than the latter as the loop has lost still more of its distinctness by becoming merged with the marginal ridge and by being locally broken.

*Occurrence.*—Birdsong shale, locality 4.

BOLLIA JUGALOIDEA Wilson, n. sp.

Plate 77, figures 6*a*, *b*

Carapace subrectangular; maximum length about midway between dorsal and ventral margins; maximum height slightly less than one-third of shell length from the anterior; dorsal margin straight; ventral margin straight for short distance and rounding smoothly into both extremities; anterior extremity forms almost a right angle with the dorsal margin and swings broadly backward to join the ventral margin; posterior extremity roundly convex. Equivalved. Free margins of both extremities bordered by high ridges that are joined by a low ridge along the ventral margin. The high ridge along the anterior extremity crosses the dorsal half of the valve normal to the hinge-line, and has only a slight posterior inclination in the ventral half. This high anterior ridge is separated from the anterior extremity by a low, broad platform. Within this marginal ridge is a loop, the dorsal-posterior end of which is bulbous, and whose bottom is connected with the low ventral part of the marginal ridge. Between the bulbous dorsal end of the loop and the ventral connection with the marginal ridge the loop is depressed.

Average measurements of syntypes: length, 1.30 mm.; height, 0.76 mm.

*Remarks.*—This species is included in

the genus *Bollia* because of its definite relationship to *B. magnoarenaria* and *B. wurmi*. The marginal ridge is depressed along the ventral margin and the loop is not as well defined as in *B. magnoarenaria*, but both marginal ridge and loop are sufficiently distinct to show derivation from a species having well developed marginal ridge and loop.

*Occurrence.*—Birdsong shale, locality 3.

Genus PLACENTELLA Wilson, n. gen.

Genotype: *Placentella delicata* Wilson, n. sp.

Carapace elliptical to subovate, generally less than 1 mm. in length; maximum length about half-way between dorsal and ventral margins; dorsal margin straight, except where a locally thickened rim may rise above the hinge-line and where the sulcus joins the margin; ventral margin slightly convex and curving smooth into both extremities; anterior and posterior extremities uniformly convex with only a slight suggestion of a backward swing on the posterior extremity. Equivalved. No articulation apparent. Surface of valve flat, or almost flat; reticulated by numerous small pits; and surrounded by a raised, unornamented marginal rim. A small, rounded node is present in the dorsal-anterior region. Posterior to this node is a small, and sometimes faint, sulcus, which extends from the dorsal margin to near the ventral side of the node.

This genus is closely related to *Jonesites* Coryell (*Placentula* Jones and Holl), but differs in possessing a small, rounded node just anterior to the sulcus and in not having a loop surrounding the sulcus as in *Jonesites*. The sulcus of *Placentella* is much more poorly developed. The name *Placentella* means "little cake."

PLACENTELLA DELICATA Wilson, n. sp.

Plate 77, figures 7*a*, *b*

Carapace small and subovate; maximum length midway between dorsal and ventral margins; maximum height two-thirds of shell length from the anterior; hinge-line straight, but the dorsal margin is locally convex posterior to the sulcus where the rim is thickened; ventral margin slightly convex and curves smoothly into both extremities; anterior extremity roundly convex; posterior extremity with a slight backward swing. Equivalved. Surface of valve almost flat; reticulated

EXPLANATION OF PLATE 78

FIGS. 1*a–d*—*Strepula bentoni* Wilson, n. sp., ×40. *a*, Ventral aspect. *b*, Right valve. *c*, Right valve. *d*, Dorsal aspect. Loc. 3. (p. 640)

2*a–e*—*Eucraterellina randolphi* Wilson, n. sp., ×25. *a*, Dorsal aspect of holotype. *b*, Dorsal aspect. *c*, Right valve of holotype. *d*, Left valve of holotype. *e*, Right valve. Loc. 2. (p. 641)

3*a*, *b*—*Thlipsurella perryvillia* Wilson, n. sp., ×25. *a*, Right valve. *b*, Left valve. Syntypes. Loc. 5. (p. 642)

4*a–d*—*Octonaria glenni* Wilson, n. sp., ×25. *a*, Right valve of holotype. *b*, Left valve. *c*, Left valve. *d*, Dorsal aspect of holotype. Loc. 5. (p. 642)

5*a*—*Rothella birdsongia* Wilson, n. sp. *a*, Left valve of holotype, ×25. Loc. 2. (p. 644)

6*a*, *b*—*Rothella obtusa* Wilson, n. sp., ×25. *a*, Right valve. *b*, Left valve. Syntypes. Loc. 5. (p. 643)

7*a–e*—*Bythocypris geisi* Wilson, n. sp., ×25. *a*, Right valve. *b*, Right valve of holotype. *c*, Left valve. *d*, Dorsal aspect of holotype. *e*, Ventral aspect of holotype. Loc. 3. (p. 645)

8*a–c*—*Bythocypris kershavii* Wilson, n. sp., ×25. *a*, Right valve. *b*, Left valve. *c*, Dorsal aspect. Holotype. Loc. 2. (p. 645)

9*a–c*—*Bythocypris parsonia* Wilson, n. sp., ×25. *a*, Left valve. *b*, Right valve. *c*, Ventral aspect. Holotype. Loc. 5. (p. 645)

10*a–d*—*Pontocypris delicata* Wilson, n. sp., ×40. *a*, Right valve. *b*, Ventral aspect of holotype. *c*, Dorsal aspect of holotype. *d*, Left valve. Loc. 4. (p. 646)

11*a*, *b*—*Microcheilinella decaturi* Wilson, n. sp., ×40. *a*, Right valve. *b*, Ventral aspect. Holotype. Loc. 4. (p. 646)

Wilson, Devonian Ostracoda

with numerous small pits; and is surrounded by an unornamented, raised marginal rim that is locally thickened along the dorsal margin posterior to the sulcus. There is a small, rounded node in the dorsal-anterior region, posterior to which is a shallow sulcus extending from the dorsal margin to a point slightly ventral to the node.

Average measurements of syntypes: length, 0.56 mm.; height, 0.38 mm.

*Occurrence.*—Birdsong shale, locality 1.

PLACENTELLA ELLIPTICA Wilson, n. sp.

Plate 77, figures 8*a*, *b*

Carapace small and elliptical; maximum length midway between dorsal and ventral margins; maximum height in anterior portion just in front of the node; dorsal margin straight except for minor irregularity at point where sulcus meets the dorsal margin; ventral margin slightly convex, meeting both extremities with smooth curves; anterior and posterior extremities roundly curved. Equivalved. Surface of valve flat; reticulated with numerous small pits; and completely surrounded by an unornamented, raised marginal rim. Small, rounded node in dorsal-anterior region, posterior to which is a very faint sulcus.

Average measurements of syntypes: length, 0.60 mm.; height, 0.35 mm.

*Occurrence.*—Birdsong shale, locality 1.

## Genus AECHMINA Jones and Holl, 1869

AECHMINA CUSPIDATA Jones and Holl

*Aechmina cuspidata* JONES and HOLL, *1869*, Annals and Mag. Nat. Hist., (4), vol. 3, p. 218, text fig. 2, pl. 14, fig. 8.—JONES, *1870*, Monthly Micr. Jour., vol. 4, p. 185, pl. 61, fig. 6; *1887*, Annals and Mag. Nat. Hist., (5), vol. 19, p. 411, pl. 13, figs. 2–4, 9. —ULRICH and BASSLER, *1913*, Maryland Geol. Survey, Lower Devonian, p. 521, pl. 95, figs. 19–21.

About 50 specimens of this species were found at locality 1.

AECHMINA SIMPLEX Ulrich and Bassler (?)

*Aechmina simplex* ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 512, pl. 38, fig. 20.

Two specimens found at locality 5 are believed to belong to this species, but they are too fragmentary to make a positive identification.

AECHMINA SPICAFERELLA Wilson, n. sp.

Plate 77, figures 9*a–e*

Carapace small and subovate; maximum length midway between dorsal and ventral margins; maximum height midway between anterior and posterior extremities; maximum breadth three-fifths of the shell length from the anterior; dorsal margin roundly curved, broken only by a small spine; dorsal aspect shows depressed, straight hinge-line and two small spines; ventral margin roundly curved; both anterior and posterior extremities symmetrically convex. Equivalved. Surface smooth except for small, sharp spine located posterior to the middle of the dorsal margin and pointing toward the posterior.

Measurements of holotype: length, 0.42 mm.; height, 0.28 mm.; breadth, 0.25 mm.

*Remarks.*—This species differs from *A. inequalis* Roth in having a very different shaped and much smaller spine, different outline, and in being only about one-third as large.

*Occurrence.*—Birdsong shale, locality 1.

## Genus PARAECHMINA Ulrich and Bassler, 1923

PARAECHMINA LACIA Wilson, n. sp.

Plate 77, figures 10*a*, *b*

Carapace subrectangular, ventral corners rounded; maximum length midway between dorsal and ventral margins; maximum height slightly posterior of center; dorsal margin straight and bearing near the center a spine that points toward the anterior; ventral margin rounds smoothly into anterior extremity, but more abruptly into posterior extremity; anterior extremity leaves the dorsal margin at an obtuse angle and swings toward the anterior for a short distance before turning backward to join the ventral margin in a symmetrical

curve; posterior extremity leaves the dorsal margin at an angle less than the anterior cardinal angle and continues backward for a little more than half the height of the valve before turning to join the ventral margin. The posterior extremity is bordered by a ridge that begins on the dorsal margin a short distance anterior to the posterior cardinal angle and ends abruptly just anterior to the ventral-posterior swing. This ridge roughly parallels the posterior extremity but does not partake in the posterior swing of that extremity, remaining some distance inside the free margin throughout the entire length. With the exception of this posterior ridge the surface of the valve slopes smoothly downward to the free margins. Near the center of the dorsal margin is a stout spine that protrudes toward the anterior extremity. Surface of valves otherwise smooth.

Average measurements of syntypes: length, 0.96 mm.; height, 0.62 mm.

*Remarks.*—This species resembles *P. inaequalis* Ulrich and Bassler in several features, but it differs from *P. inaequalis* in having the posterior ridge set back some distance from the free margin and not as a marginal ridge, in not having a slightly raised margin in the anterior half, and in having the dorsal spine protrude toward the anterior at a low angle rather than almost vertically upward with only a slight anterior component, as does the spine on *P. inaequalis.*

*Occurrence.*— Birdsong shale, locality 1.

## Family Beyrichiidae Jones

### Genus Ctenobolbina Ulrich, 1890

#### Ctenobolbina granosa Ulrich

*Ctenobolbina granosa* Ulrich, *1900*, Cincinnati Soc. Nat. Hist., Jour., vol. 19, p. 183, pl. 8, fig. 12.—Ulrich and Bassler, *1909*, U. S. Nat. Mus., Proc., vol. 35, p. 310, pl. 40, fig. 12.

The collection from locality 2 contains three well preserved specimens of this species.

## Family Kirkbyidae Ulrich and Bassler

### Genus Amphissites Girty, 1910

#### Amphissites retiferus Roth

*Amphissites retiferus* Roth, *1929*, Jour. Paleontology, vol. 3, p. 348, pl. 36, fig. 11.

This species is well represented in the collections from the Birdsong shale.

#### Amphissites primaevus Roth

*Amphissites primaevus* Roth, *1929*, Jour. Paleontology, vol. 3, p. 346, pl. 36, fig. 10.

A few specimens found at locality 2 are thought to belong to this species.

#### Amphissites planus Wilson, n. sp.

Plate 77, figures 11*a–d*

Carapace subovate; maximum length approximately midway between dorsal and ventral margins; maximum height one-third the shell length from the anterior; specimens apparently have uniform breadth the entire length of valves; dorsal margin straight or slightly convex; ventral margin gradually curves downward from ventral-posterior curve and forms a pronounced "backward" swing as it turns upward into the anterior extremity; ventral aspect shows the flat surfaces of both valves parallel to each other. Free margins of venter are paralleled by poorly developed keels. Anterior extremity is characterized by a "backward" swing that reaches its most anterior position about one-half the distance from the dorsal margin to the ventral margin, from which point it swings upward and backward to form the obtuse anterior cardinal angle. Posterior extremity is a fairly symmetrical curve that reaches its most posterior position one-third the distance between the dorsal and the ventral margins, from which point it gradually curves downward and forward into the ventral margin. Overlap is indicated by a small ridge, or flange, on the free margins of the left valve that probably fits into a corresponding groove on the free margins of the right valve. Surface is reticulated with large, closely spaced pits. The kirkbyan pit is well de-

veloped and is located close to the center of the valve.

Measurements of typical specimens: length, 0.88 to 1.00 mm.; height, 0.56 to 0.68 mm.; breadth, 0.40 to 0.46 mm.

*Remarks.*—This species is closer to *A. retiferus* Roth than any other previously described species, but it differs from *A. retiferus* by having the surfaces of both valves flat and parallel to each other, the dorsal margin and free margins being approximately normal to the surface of the valve. The valves of *A. retiferus* have convex surfaces that rise from the margins and curve smoothly up to the point of greatest breadth.

*Occurrence.*—Birdsong shale, locality 2.

### Genus KIRKBYELLA Coryell and Booth, 1933

#### KIRKBYELLA PERPLEXA Wilson, n. sp.
Plate 77, figures 12*a–d*

Carapace small and subrectangular; maximum length midway between dorsal and ventral margins; maximum height approximately two-thirds the shell length from the anterior and posterior extremities; maximum breadth slightly more than two-thirds the shell length from the anterior and posterior extremities; dorsal margin straight, except for slight convexity above the hinge line posterior to the sulcus; ventral margin straight for short distance, curving smoothly into anterior extremity and turning abruptly into the posterior extremity; ventral aspect shows a false keel on each valve near the free margin; anterior extremity leaves the dorsal margin at a slightly obtuse angle, continues toward the most anterior point, and curves roundly into the ventral margin; posterior extremity leaves dorsal margin at approximately a right angle, continues with a very slight convex swing, and curves abruptly into the ventral margin. Equivalved, except for slight rabbetting of free margins of right valve to be overlapped by left valve. Surface reticulated with numerous small pits. A distinct sulcus occurs a short distance anterior to the center of the valve. Sulcus may be normal to the hinge-line or slightly inclined toward the posterior. A low ridge, which is parallel to the hinge-line and just ventral to the end of the sulcus, rises above the convex level of the valve and ends posteriorly in a small spine.

Measurements of holotype: length, 0.75 mm.; height, 0.45 mm.; breadth, 0.38 mm.

*Remarks.*—This species has general features in common with both *K. verticalis* Coryell and Cuskley and *K. obliqua* Coryell and Cuskley, but differs from both by not having a narrow, unreticulated border around the free margins.

*Occurrence.*—Birdsong shale, localities 1, 3, and 5.

#### KIRKBYELLA MAGNOPUNCTATA Wilson, n. sp.
Plate 77, figures 13*a*, *b*

Carapace small and subrectangular; maximum length a short distance below dorsal margin; maximum height between sulcus and anterior extremity; dorsal margin generally straight except for slight re-entrant above the sulcus and a slight convexity posterior to the sulcus; ventral margin straight, curving roundly into the anterior extremity, but meeting the posterior extremity with an obtuse angle; ventral aspect shows a false border on each valve; posterior extremity extends straight from ventral-posterior angle to most posterior position, where it turns back to make the dorsal-posterior angle. A small protuberance extends toward the posterior from the posterior cardinal angle. Anterior extremity leaves the dorsal margin at an angle slightly greater than a right angle and forms a convex curve before joining the ventral margin. Posterior aspect rectangular. No overlap or articulation apparent. Surface marked by a deep sulcus located anterior to the center; by a raised, unornamented, thick border; by coarse reticulations within the borders (four of these reticulations occur between the sulcus and posterior, and three between

the sulcus and anterior); and by a raised, unornamented ridge just ventral to the end of the sulcus and extending across most of the distance between extremities. Surface of valve almost flat.

Measurements of figured specimens: length, 0.62 mm.; height, 0.32 mm.–0.37 mm.

*Remarks.*—This species differs from *K. obliqua* Coryell and Cuskley by having the lateral ridge that is just ventral to the sulcus unornamented, by having this lateral ridge flatten out at both ends and not ending in a spine as the similar ridge does on *K. obliqua*, and by having fewer and much larger pits.

*Occurrence.*—Birdsong shale, locality 1.

### Genus STREPULA Jones and Holl, 1886

#### STREPULA BENTONI Wilson, n. sp.

Plate 78, figures 1*a–d*

Carapace elongate subrectangular; maximum length about midway between dorsal and ventral margins; maximum height about four-fifths the shell length from the anterior; dorsal margin straight; ventral margin straight in anterior half, but convex in posterior half; anterior extremity slightly convex and forms abrupt angles with both dorsal and ventral margins; posterior extremity with backward swing. Essentially equivalved. A low ridge borders the free margins. On the surface of the valve are three narrow, high ridges. One of these ridges rises above the marginal rim along the ventral-anterior margin and protrudes as a spine beyond the limits of the valve. The second is a straight ridge that occurs in the dorsal-anterior quadrant of the valve and is parallel to the hinge-line. The third ridge forms an arc in the posterior portion of the valve with its concave side facing the posterior extremity with a slight component toward the dorsal margin.

Average measurements of figured specimens: length, 0.80 mm.; height, 0.38 mm.; breadth, 0.32 mm.

*Remarks.*—The outline and general features of this species place it in the family Kirkbyidae. It is tentatively placed in the genus *Strepula*.

*Occurrence.*—Birdsong shale, locality 3.

## Family THLIPSURIDAE Jones

### Genus THLIPSURA Jones and Holl, 1869

#### THLIPSURA FURCA Roth

*Thlipsura furca* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 356, pl. 37, figs. 18*a–c*.

This species is abundantly represented in the Birdsong collection from localities 1 and 5. As the depressed area with the two finger-like extensions is on the thick end of the carapace, it is believed that the depressed area is posterior, rather than anterior as shown by Roth.

### Genus EUCRATERELLINA Wilson, n. gen.

*Craterellina* ULRICH and BASSLER (part), *1913*, Maryland Geol. Survey, Lower Devonian, pp. 539, 540.—ROTH, *1929*, Jour. Paleontology, vol. 3, pp. 362, 363.

*Thlipsurella* SWARTZ (section of *T. oblonga*), *1932*, Jour. Paleontology, vol. 6, pp. 45–48.

Genotype: *Eucraterellina randolphi* Wilson, n. sp.

Carapace subovate to subreniform, generally 1 mm. or less in length; moderately thick, with greatest thickness in posterior portion; maximum height in posterior portion, or posterior to center; dorsal margin slightly convex to strongly convex; ventral margin nearly straight. Left valve larger and overlaps the right valve. No articulation apparent. Surface of valves smooth with exception of deep posterior crater that is completely surrounded by a distinct rim at the general level of the surface of the valve. Crater may be simple or partially occupied by either vari-shaped prolongations of the general level of the valves or by isolated nodes rising from the floor of the crater.

In 1913 Ulrich and Bassler described the genus *Craterellina* with the genotype *C. robusta* and another species, *C. oblonga*, both from the Shriver chert (Oriskany) of Maryland. In 1929 Roth added *C. moorei* to this genus, this species occurring in the Haragan marl (Helderberg) of Oklahoma.

Swartz, in 1932, examined specimens from the Shriver chert of Maryland and Pennsylvania and found that the "crater," or depressed area, of the genotype of *Craterellina* was not bounded by a rim, but instead was "open to the *front*" (I reverse the orientation, as explained later, making the depressed area posterior). On this basis *Craterellina* was abandoned, as the genotype did not show the most diagnostic feature of the genus, the crater completely surrounded by a distinct rim. Swartz placed the genotype, *C. robusta*, in the genus *Thlipsura*. *C. oblonga* Ulrich and Bassler, *C. moorei* Roth, and two new species, *Thlipsurella orthoclefta* Swartz and *T. crateriformis* Swartz, both from the Shriver chert of Pennsylvania, were grouped together in the "section of *Thlipsurella oblonga* (Ulrich and Bassler)."

In 1934 I found specimens in the Birdsong shale of Tennessee very similar to the described genotype of "*Craterellina*," and possessing a crater completely surrounded by a distinct rim. The simplest solution to this problem of nomenclature would have been to restore the validity of "*Craterellina*," but this could not be done because the genotype "*C. robusta* did not possess the features ascribed to it, and the genus could not be restored without using the original genotype.

For this reason and also because the section of *Thlipsurella oblonga* and the new species from the Birdsong shale possess the important feature of a crater completely surrounded by a distinct rim, I believe a new genus, including these species, is necessary. The difference in age ("*Craterellina*" *Thlipsura robusta* being Oriskany and *Eucraterellina randolphi* being Helderberg) is thought to be too slight to trace the derivation of the former from the latter. These two species, however, possess many features in common and it is safe to say that through them the genera *Thlipsura* and *Eucraterellina* are related, possibly the former having been derived from the latter.

As all the species belonging to *Eucraterellina* have the crater on the thicker end, the orientation of these species is reversed from that used by Ulrich and Bassler, Roth, and Swartz. The new orientation, here proposed, places the crater on the posterior rather than on the anterior end.

Species grouped in this genus include:

*Eucraterellina randolphi* Wilson, n. sp. and genotype
*Eucraterellina oblonga* (Ulrich and Bassler)
*Eucraterellina moorei* (Roth)
*Eucraterellina crateriformis* (Swartz)
*Eucraterellina orthoclefta* (Swartz)

The name of the new genus signifies "new or true *Craterellina*."

EUCRATERELLINA RANDOLPHI Wilson, n. sp.
Plate 78, figures 2*a–e*

Carapace subreniform; maximum length approximately midway between dorsal and ventral margins; maximum height approximately two-thirds the shell length from the anterior to the posterior extremity; maximum breadth is two-thirds the distance from anterior to posterior extremity and coincides with the anterior side of the crater; dorsal margin strongly convex in most specimens and slopes gradually forward and more abruptly backward; dorsal aspect shows the abrupt broadening of the specimen, which begins midway between extremities, the crater with its surrounding rim, and the two rounded, isolated nodes rising above the floor of the crater; ventral margin is straight or slightly concave near the center; ventral aspect shows the same features as the dorsal aspect but in addition may be seen the slight overlap of the larger left valve; anterior extremity smoothly rounded and reaching most anterior position between dorsal-anterior corner and the mid-line; posterior extremity more broadly rounded, joining the ventral margin more abruptly than the dorsal margin. The left valve is slightly larger and overlaps the right valve. Surface of valve is smooth, and broken only by the posterior crater. Within the crater two rounded

nodes rise above the floor of the crater. On the anterior side of the crater a V-shaped salient of the general level of the valve extends out into the crater in the direction of the inter-node space.

Measurements of holotype: length, 0.92 mm.; height, 0.60 mm.; breadth, 0.51 mm.

*Occurrence.*—Birdsong shale, locality 2.

EUCRATERELLINA MOOREI (Roth)

*Eucraterellina moorei* (ROTH), *1929*, Jour. Paleontology, vol. 3, p. 362, pl. 37, figs. 22*a*, *b*.

This species is common in the Birdsong collection from locality 1.

Genus THLIPSURELLA F. M. Swartz, 1932

THLIPSURELLA FOSSATA (Roth)

*Thlipsurella fossata* (ROTH), *1929*, Jour. Paleontology, vol. 3, p. 355, pl. 36, figs. 16*a–c*.

Several good specimens of this species were found in the Birdsong shale at locality 2.

THLIPSURELLA CURVISTRIATA (Roth)

*Thlipsurella curvistriata* (ROTH), *1929*, Jour. Paleontology, vol. 3, p. 354, pl. 36, figs. 15*a*, *b*.

This species is represented by several specimens from locality 4.

THLIPSURELLA PERRYVILLIA Wilson, n. sp.
Plate 78, figures 3*a*, *b*

Carapace subreniform; maximum length midway between dorsal and ventral margins, or slightly ventral to the mid-line; maximum height posterior to center of valve; maximum breadth about two-thirds the shell length from the anterior extremity; dorsal margin slopes gradually forward from point of greatest height to anterior extremity, and from point of greatest height backward to posterior extremity; dorsal aspect shows the slightly thickened posterior extremity and the lateral ridge; ventral margin approximately straight; anterior extremity curves more or less symmetrically into both margins; posterior extremity curves abruptly upward from the ventral-posterior corner to the most posterior position from where it continues in a slightly convex line to the point of greatest height on the dorsal margin. Surface of valve is smooth except for a pronounced ridge that parallels the long axis of the carapace for from half to two-thirds the length of the carapace. This ridge rises sharply above the convex surface of the valve.

Measurements of syntypes: length, 1.10 mm.; height, 0.60–0.72 mm.

*Remarks.*—This species resembles *Thlipsurella striatopunctata* (Roth) more than any other described species, but it differs in not possessing "two more or less parallel furrows extending across fully two-thirds of the anterior portion of the valve," in not possessing a "ridge (which) more or less parallels the inclined anterior extremity," and in being more elongate.

As the more acute extremity is the thicker it is taken to be the posterior.

*Occurrence.*—Birdsong shale, locality 5.

Genus OCTONARIA Jones, 1887

OCTONARIA GLENNI Wilson, n. sp.
Plate 78, figures 4*a–d*

Carapace subreniform; maximum length midway between dorsal and ventral margins; maximum height approximately midway between anterior and posterior extremities; maximum breadth two-thirds the distance between anterior and posterior extremities; dorsal margin roundly convex, swinging smoothly into the dorsal-anterior curve immediately in front of the highest point but continuing gradually back from the highest point for some distance before abruptly turning the dorsal-posterior corner; ventral margin straight except for small concave swing near the center. Left valve slightly larger and overlaps right valve. Surface of valves marked by a raised ridge that begins near the highest point along the dorsal margin and continues by paralleling the anterior extremity, ventral margin, and posterior extremity at some distance in from the rim of the valve. Between the mid-line and the dorsal-

posterior corner the ridge splits into two ridges that abruptly turn forward and continue across the valve until they again unite into one ridge which extends a short distance toward the ventral-anterior corner, stopping before reaching the ridge paralleling the margins.

Measurements of holotype: length, 0.88 mm.; height, 0.52 mm.; breadth, 0.39 mm.

*Remarks.*—This species is similar to *O. inaequalis* Ulrich and Bassler in outline and general characters, but differs markedly in the pattern of the ridge. *O. glenni* is closely related to the figure of *O. stigmata* Ulrich included in a report on the Onondaga fauna by Kindle (3). Kindle's figure, however, is very different from the figures of the original describer. The species from the Birdsong shale differs greatly from the original *O. stigmata* Ulrich and also to a less extent from "*O. stigmata*" figured by Kindle in possessing a very different pattern of the ridge.

*Occurrence.*—Birdsong shale, localities 1 and 5.

Genus ROTHELLA Wilson, n. gen.

*Dizygopleura* ROTH (part), *1929*, Jour. Paleontology, vol. 3, pp. 344–346.

Genotype: *Rothella recta* (Roth).

Carapace subrectangular, generally between 1 and 2 mm. in length; greatest thickness in the vicinity of posterior crater; maximum length approximately midway between dorsal and ventral margins; maximum height in vicinity of posterior crater; dorsal margin straight or slightly convex; dorsal aspect subrectangular; ventral margin straight or slightly concave. Left valve larger and overlaps the right valve along the free margins. No articulation apparent. Surface of valves marked by an anterior crater and a posterior crater which are usually elongated but sometimes round. These craters may be completely surrounded by a raised rim; may have a raised ridge, or lip, on only one side; or may have no associated ridge. A broad circular spot may be present near the center of the valve.

In 1929 Roth described two species, *Dizygopleura recta* and *D. obliqua*, from the Haragan marl of Oklahoma, with some question as to the generic relations. Swartz (4) recognized that these species did not belong to the genus *Dizygopleura*.

The only existing genus to which these species are closely related is *Phreatura* Jones and Kirkby. Roth, however, gave conclusive reasons for not including his two species in this genus. I agree with Roth in this conclusion and here erect a new genus, *Rothella*, named in his honor, to contain:

*Rothella recta* (Roth), genotype
*Rothella obliqua* (Roth)
*Rothella obtusa* Wilson
*Rothella birdsongia* Wilson

ROTHELLA RECTA (Roth)

*Dizygopleura recta* (ROTH), *1929*, Jour. Paleontology, vol. 3, p. 344, pl. 36, figs. 8*a–c*.

This species is common in the writer's collection from locality 1.

ROTHELLA OBLIQUA (Roth)

*Dizygopleura obliqua* (ROTH), *1929*, Jour. Paleontology, vol. 3, p. 346, pl. 36, figs. 9*a*, *b*.

Specimens of this species occur in the collection from the Birdsong shale at locality 1.

ROTHELLA OBTUSA Wilson, n. sp.
Plate 78, figures 6*a*, *b*

Carapace subrectangular; maximum length slightly ventral to mid-line between dorsal and ventral margins; maximum breadth in vicinity of posterior, or better developed, crater; dorsal margin straight, or slightly convex for short distance, but the anterior third swings gently downward to join the anterior extremity; dorsal aspect subrectangular, with the four pronounced ridges surrounding the craters; ventral margin straight or slightly concave near center; anterior extremity reaches most anterior position about two-thirds the distance between dorsal and ventral margins, from which point it gently swings into the dorsal-anterior corner, and from

which point it curves abruptly to join the ventral-anterior corner; posterior extremity broadly convex with a backward swing, joining both margins abruptly. Left valve larger and overlaps the right valve along the free margins. Surface marked by two elongated oval craters. The crater occupying the posterior portion of the valve is completely surrounded by a distinct ridge that rises high above the level of the valve, and is twice as long and wide as the crater occupying the anterior portion. The ridge surrounding the anterior crater is low and not pronounced.

Measurements of syntypes: length, 1.16–1.36 mm.; height, 0.78–0.88 mm.

*Remarks.*—The nearest existing species to this new one is *Rothella obliqua* (Roth). The major differences between these two are the much shorter and higher carapace of *Rothella obtusa*, and the inequal development of the craters in *R. obtusa*.

*Occurrence.*—Birdsong shale, locality 5.

ROTHELLA BIRDSONGIA Wilson, n. sp.
Plate 78, figure 5*a*

Carapace subrectangular, but with dorsal-anterior corner rounded; maximum length midway between dorsal and ventral margins; maximum height and breadth in vicinity of posterior crater; dorsal margin straight, but rising to a slightly convex curve at the point of maximum height; dorsal aspect subrectangular, showing the lips on the posterior side of the posterior crater; ventral margin straight, but slightly concave near center; anterior extremity reaches most anterior position about two-thirds the distance between dorsal and ventral margins, from which point it gently swings into the dorsal-anterior corner, and from which point it swings to join abruptly the ventral-anterior corner; posterior extremity broadly convex and with a backward swing. As only single valves were found there is no evidence for relative size of valves and overlap. Surface marked by two craters. The posterior crater is elongated obliquely, becoming deeper toward the ventral-posterior corner, and has a raised lip, or ridge, only on the posterior and ventral-posterior sides. The anterior crater is a small, round depression with no raised rim.

Measurements of holotype: length, 1.30 mm.; height, 0.76 mm.

*Occurrence.*—Birdsong shale, locality 2

Genus PHANASSYMETRIA Roth, 1929

PHANASSYMETRIA TRISERRATA Roth

*Phanassymetria triserrata* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 358, pl. 37, figs. 20*a–c*.

This species is abundantly represented from localities 3 and 4.

PHANASSYMETRIA QUADRUPLA Roth

*Phanassymetria quadrupla* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 360, pl. 37, figs. 21*a–c*.

Specimens of this species are common in the collections from localities 3 and 5.

## Family BAIRDIIDAE Lienenklaus

Genus BYTHOCYPRIS Brady, 1880

BYTHOCYPRIS INDIANENSIS Ulrich

*Bythocypris indianensis* ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 197, pl. 16, figs. 11*a–c*.

Abundantly represented from localities 1 and 5.

BYTHOCYPRIS SIMPLEX Roth

*Bythocypris simplex* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 366, pl. 38, figs. 25*a*, *b*.

This species is well represented in the collections from localities 1 and 5. *B. simplex* resembles *B. indianensis* in most of the major features.

BYTHOCYPRIS DEVONICA Ulrich

*Bythocypris devonica* ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 196, pl. 17, figs. 1*a–c*.

Several specimens of this species were found in the collection from locality 5.

BYTHOCYPRIS TRANSVERSA Roth

*Bythocypris transversa* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 365, pl. 37, figs. 24*a–c*.

This species is present in the material collected from locality 5. It resembles *B. devonica* in many respects.

BYTHOCYPRIS SYMMETRICA Jones

*Bythocypris symmetrica* JONES, *1887*, Annals Mag. Nat. Hist., (5), vol. 19, p. 186, pl. 7, figs. 3, 4, 7.—KRAUSE, *1891*, Deutsch. geol. Ges., Zeitschr., vol. 43, p. 511, pl. 33, fig. 6.

In the collections from localities 3 and 5 there are several specimens of *Bythocypris* that the present writer cannot differentiate from the species described and figured by Jones and by Krause from the upper and lower Wenlock shale of England and the *Encrinurus* kalk of Germany, respectively.

BYTHOCYPRIS HOLLII Jones

*Bythocypris hollii* JONES, *1887*, Annals Mag. Nat. Hist., (5), vol. 19, p. 184, pl. 5, figs. 1, 2; pl. 6, figs. 3, 4.—KRAUSE, *1891*, Deutsch. geol. Ges., Zeitschr., vol. 43, p. 511, pl. 33, fig. 5.

Several specimens of *Bythocypris* which are identical to *B. hollii* as described by Jones, with the single exception of being slightly smaller, were found in the collection from locality 3. The descriptions and figures of Krause for this same species differ in several respects; but as the description by Jones is the original, the present writer includes his specimens in this species. *B. hollii* Jones was described from the upper Wenlock shale of England.

BYTHOCYPRIS GEISI Wilson, n. sp.
Plate 78, figures 7*a–e*

Carapace small and elongate; maximum length two-thirds the distance between dorsal and ventral margins; maximum height approximately three-fifths the shell length from the anterior; maximum breadth approximately two-thirds the distance between the anterior and posterior extremities; dorsal margin convex with highest point at position of maximum height; dorsal aspect shows a uniform tapering posterior to the line of maximum breadth, and a more gradual tapering anterior to the line of maximum breadth; ventral margin of left valve approximately straight, and ventral margin of right valve slightly concave; anterior extremity a symmetrical curve; posterior extremity pointed in the ventral third of the extremity. Left valve larger and overlaps right valve. Surface smooth.

Measurements of holotype: length, 0.88 mm.; height, 0.41 mm.; breadth, 0.40 mm.

*Remarks.*—This species is unlike any previously described species. Its elongated and pointed posterior extremity is suggestive of members of the genus *Bairdia*.

*Occurrence.*—Birdsong shale, localities 3 and 5.

BYTHOCYPRIS KERSHAVII Wilson, n. sp.
Plate 78, figures 8*a–c*

Carapace large and subreniform; maximum length three-fifths the distance between dorsal and ventral margins; maximum height and breadth approximately two-thirds the shell length from the anterior; dorsal margin rounds smoothly into posterior extremity from point of maximum height, but anterior to the point of maximum height the margin continues straight or only very slightly convex for some distance before meeting the anterior extremity; ventral margin slightly convex; anterior extremity symmetrically rounded; posterior extremity broadly convex from dorsal-posterior corner to the most posterior point, from where it abruptly turns into the ventral margin. Left valve larger and overlaps the right valve on all sides, overlap being less on the extremities. Surface smooth.

Measurements of holotype: length, 1.55 mm.; height, 0.88 mm.; breadth, 0.60 mm.

*Occurrence.*—Birdsong shale, locality 2.

BYTHOCYPRIS PARSONIA Wilson, n. sp.
Plate 78, figures 9*a–c*

Carapace subreniform; maximum length three-fifths the distance between dorsal and ventral margins; maximum height and breadth approximately two-thirds

the shell length from the anterior extremity; dorsal margin gently convex; ventral margin approximately straight; anterior extremity symmetrically curved; posterior extremity more broadly curved, and with sharper swing on ventral-posterior portion than on dorsal-posterior portion. Left valve larger and overlaps the right valve. Surface smooth.

Measurements of holotype: length, 1.50 mm.; height, 0.68 mm.; breadth, 0.56 mm.

*Remarks.*—This species resembles *B. cylindrica* Hall and *B. testacella* Jones, but differs from both in details of outline and overlap.

*Occurrence.*—Birdsong shale, locality 5.

### Genus PONTOCYPRIS M. Sars, 1865

#### PONTOCYPRIS DELICATA Wilson, n. sp.

Plate 78, figures 10*a–d*

Carapace small and ovate; maximum length about two-thirds the distance between dorsal and ventral margins; maximum height and breadth approximately two-thirds the shell length from the anterior; dorsal margin asymmetrically convex, curving sharply to posterior extremity and gently to anterior extremity from point of maximum height; dorsal aspect shows a semicircular posterior extremity, and a long convex tapering from the point of maximum breadth to the pointed anterior extremity; ventral margin straight for short distance near the center; anterior extremity sharply rounded, reaching most anterior position about two-thirds the distance between dorsal and ventral margins; posterior extremity broadly convex, with ventral-posterior swing more abrupt than dorsal-posterior swing. Overlap not discernible. Surface smooth.

Measurements of holotype: length, 0.50 mm.; height, 0.32 mm.; breadth, 0.25 mm.

*Occurrence.*—Birdsong shale, locality 4.

## Family CYPRIDAE Zenker

### Genus CONDRACYPRIS Roth, 1929

#### CONDRACYPRIS SIMPLEX Roth

*Condracypris simplex* ROTH, *1929*, Jour. Paleontology, vol. 3, p. 371, pl. 38, figs. 29*a–c*.

Two specimens of this species were found in the collection from locality 5.

## Family CYTHERELLIDAE Sars

### Genus PACHYDOMELLA Ulrich, 1913

#### PACHYDOMELLA LONGULA Ulrich and Bassler

*Pachydomella longula* ULRICH and BASSLER, *1913*, Maryland Geol. Survey, Lower Devonian, p. 542, pl. 98, figs. 29–31.

Three well preserved specimens of this species were found at locality 4.

### Genus MICROCHEILINELLA Geis, 1932

#### MICROCHEILINELLA DECATURI Wilson, n. sp.

Plate 78, figures 11*a*, *b*

Carapace elliptical; maximum length midway between dorsal and ventral margins; maximum height and breadth three-fifths the shell length from the anterior extremity; dorsal margin slightly convex; dorsal aspect shows a sharp anterior extremity and a broadly curved posterior extremity; ventral margin straight; anterior and posterior extremities smoothly rounded. The position of greatest convexity differs in the two valves, being dorsal in the right valve and ventral in the left valve. Left valve larger and overlaps the right. Surface smooth.

Measurements of holotype: length, 0.62 mm.; height, 0.36 mm.; breadth, 0.37 mm.

*Occurrence.*—Birdsong shale, locality 4.

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JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 8, PP. 647–652, PL. 79, DECEMBER, 1935

# *SCHWAGERINA* FROM THE WESTERN EDGE OF THE RED BASIN, CHINA

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In this paper a new species of *Schwagerina* from near Mt. Omei in western China is described and illustrated, its relationship to other members of that genus are considered, and the fossils found in association with it are briefly discussed and part of them are illustrated. This is the first species of Permian fusulinids to be described from the large province of Szechuan.

In 1923, when C. L. Foster (2) published his *Notes on Szechuan Geology*, he mentioned the discovery of *Schwagerina* in the vicinity of Mt. Omei, on the western edge of the Red Basin. Permian fusulinids are known to occur to the northwest of Szechuan in Tibet (Kukunor), to the north in Kansu, to the northeast in Honan and Shansi, to the east in Hupeh, to the southeast in Hunan, Kweichow, and Kwangsi, and to the south in Yunnan, but in so far as we have been able to ascertain this is the only published record of Permian fusulinids in the large province of Szechuan[1] and, therefore, it merits amplification. Professor Foster kindly made available for study the fusulinid material which he obtained in this remote region while he was serving as a missionary there, and we wish to take this opportunity to express our sincere thanks to him for entrusting us with these valuable specimens. Thanks are due also to Professor C. O. Dunbar who read our manuscript and offered constructive criticisms.

In regard to the occurrence of the schwagerinids, Foster states:

> About 5 miles north of the Omei spur known as Sī Chi P'in is another known as Shin K'ai Sī. This is one of the foreign summer resorts for this region of Szechuan. It reaches an elevation of about 5,500 feet. Reference has already been made to the occurrence of porphyry on this spur, intruded beneath the red shales which have been tilted and baked by it. A fault at the east foot of this spur brings vertically bedded limestone against the tilted red shales. Fossils have not been collected in this section. But near the top of the spur, especially near the bungalow known as "Rocky Roost," several have been gathered. Those most common there are Productus and Bryozoa. . . . At lower horizons were found the ones noted below:
>
> *Schwagerina* sp.
> *Leptodus* sp.
> *Cystiphyllum* sp.
> *Cyathyphyllum* sp.
> *Syringopora* sp.

Three hand-specimens of the *Schwagerina*-bearing limestone were submitted to us for study. All of these came from the same bed. The limestone is black in color, but

[1] In 1899 Lörenthey (*Wissenschaftliche Ergebnisse der Reise des Grafen Béla Széchenyi in Ostasien*, Bd. 3, p. 253) noted a single fusulinid in a thin-section of limestone, which he regarded as "Permo-Carboniferous" in age, from the extreme western part of Szechuan near Batang, but in 1902 Schwellwien (*Schrift physik.-ökono. Gesell. König.*, Jahrg. 43, p. 74) pointed out that this limestone may be referable to the Upper Carboniferous.

weathers to a light gray. It is crystalline, but being fine-grained, is compact and dense. It contains a small amount of shale but about 95 per cent of it is soluble in hydrochloric acid. However, one of the hand-specimens contains two small nodules of white chert.

Fossils are abundant in all three of the specimens being studied. Most of these are fusulinids but two or three other types of foraminifera are not rare and bryozoans are present. Some of the foraminifera apparently represent the genus *Cribrogenerina* Schubert and others are probably referable to *Endothyra* Phillips (see Pl. 79, figs. 8 and 9). All of the fusulinids are probably conspecific and we are proposing the name *Schwagerina fosteri* for them. However, one of the specimens sectioned, apparently an immature individual, has a large proloculum and rapidly expanding inner volutions (see Pl. 79, fig. 7) and it is either an abnormal individual of *S. fosteri* or it represents a distinct species.

The fusulinids offer the best available clue as to the age of the Szechuan *Schwagerina*-bearing beds. The genus *Schwagerina* is generally believed to be diagnostic of the Lower and Middle Permian. In 1924 Beede and Kniker (1, p. 78) concluded that we should regard the strata in which *Schwagerina* makes its first appearance as the base of the Permian. However, representatives of this genus have since been reported by several workers from strata which they believed to be Upper Carboniferous in age.

At least fourteen distinct species (or varieties) of *Schwagerina* have been described. Almost all of these came from strata that are now generally regarded as Permian in age. In America the genus is not known to occur below the Wolfcamp formation[2] of western Texas, the Wichita series[3] of north-central Texas, and the Big Blue series of Kansas and Nebraska. Fredericks (3) and Lich-

[2] Beede and Kniker (1, p. 54) have reported two species of *Schwagerina* from beds that are now placed in the upper portion of the Pennsylvanian Gaptank formation of western Texas, and White (7) has reported a third from the same general horizon and locality; however, King (4) has recently stated that these authors were "in error as to the horizons of their material," and Dunbar (Personal communication dated February 7, 1935) has assured us that their specimens came from the overlying Permian Wolfcamp formation.

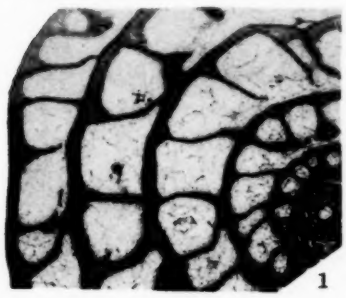
[3] Representatives of this genus have recently been reported by G. G. Henderson (*Univ. Texas, Bull.* 3232, p. 237, pl. 5, figs. 4–6, 1932) from the Moran formation of north-central Texas. This formation was formerly placed in the Pennsylvanian Cisco group, but it is now generally considered to be Permian in age, and the schwagerinids found in it are said to be in part, at least, intermediate between *Triticites* and *Schwagerina*.

EXPLANATION OF PLATE 79

All specimens illustrated on this plate came from near Mt. Omei on the western edge of the Red Basin, in the province of Szechuan, western China. All figures are unretouched photographs.

FIGS. 1–7—*Schwagerina fosteri* Thompson and Miller, n. sp. 1, Sagittal section, ×20; 2, axial section, ×10; 3, section tangential to sixth volution, ×40; 4, axial section, ×10; 5, sagittal section, ×10; 6, external view of a young specimen, ×8; 7, axial section of a small specimen which we are referring to this species with question, ×10. (p. 650)

8, 9—*Endothyra?* sp. Axial and sagittal sections, ×20. (p. 648)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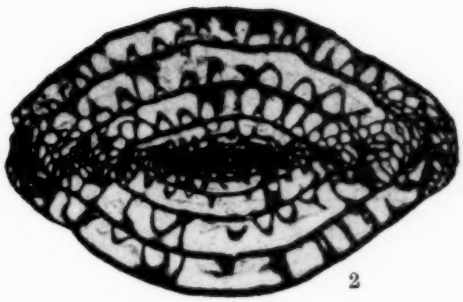
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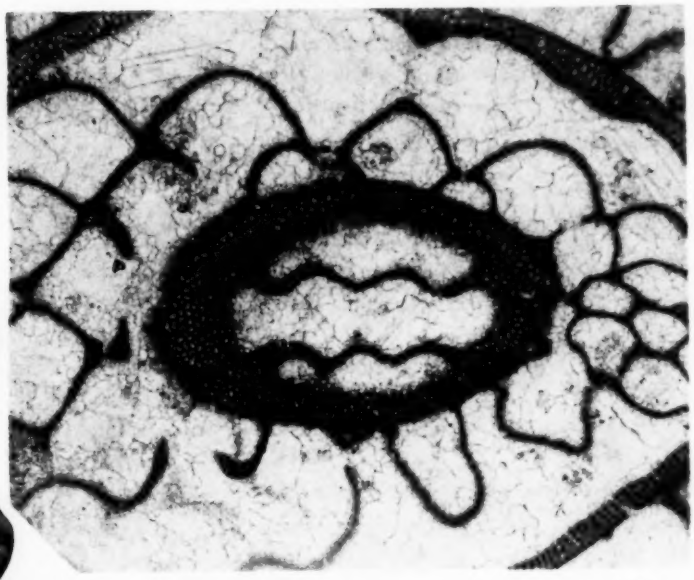
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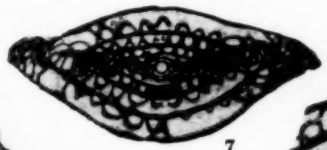
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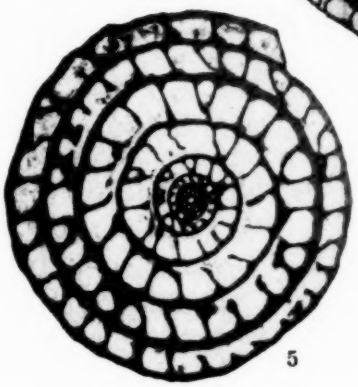
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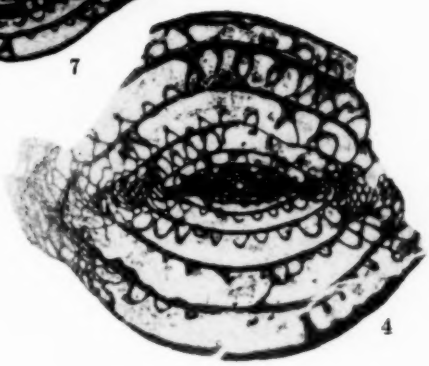
4

Thompson and Miller, Permian Fusulinids

arew (5) have reported *Schwagerina* from the Upper Carboniferous of Russia and the Russian paleontologists state that *Schwagerina* makes its appearance in the Uralian;[4] however, the age of the Uralian is at present a moot question, and it seems very doubtful to us if *Schwagerina* appears in Russia much earlier than it does in America. It should be noted in this connection that Licharew correlates his Uralian beds with the Taiyuan series of northern China which contains fusulinid faunas similar to those of the Wolfcamp formation of Texas and the lower part of the Big Blue series of Kansas and Nebraska.

During the Permian the schwagerinids appear to have undergone considerable development. However, as was suggested by Beede and Kniker (1, p. 10), the genus *Schwagerina* may be diphyletic, for the species which are now generally referred to it seem to be divisible into two groups. In one of these the juvenarium has a large form ratio and, being rather loosely coiled, is not sharply set off from the rest of the shell; also, in this group the septa are very weakly fluted. In the second group the septa are strongly fluted, and the juvenarium has a small form ratio and even though it consists of more volutions than does that of the first group it is small and is very tightly coiled. *S. fosteri* belongs to the second group which also includes such species as *S. kansasensis* Beede and Kniker, *S. tinvenkiangi* Lee, *S. gigantea* White, *S. princeps* Möller (Ehrenberg?), and *S. yabei* Staff. The stratigraphic relationships of many of the *Schwagerina*-bearing beds are very uncertain, and therefore it is difficult to determine evolutionary trends within the genus that may have chronological value. However, *S. fosteri* is closely similar to *S. tinvenkiangi* of the upper Taiyuan series (Lower Permian) of northern China and *S. kansasensis* of the Big Blue series (Lower Permian) of Kansas and the Wolfcamp formation (Lower Permian) of Texas; and it appears to be much more primitive than *S. yabei* of the Sosio beds (Middle Permian) of Sicily. The available evidence therefore may be said to indicate that the *Schwagerina*-bearing beds of the Mt. Omei region are Lower Permian in age and are the approximate time equivalent of part of the upper Taiyuan series, the Big Blue series, and the Wolfcamp formation. However, it should be pointed out in this connection that primitive forms commonly continue to exist alongside of their more advanced descendants; therefore an age-determination based on only one species is not to be relied upon implicitly, and the beds which yielded *S. fosteri* may be somewhat younger than we have indicated.

The type specimens of *Borelis princeps* Ehrenberg,[5] the genotype

[4] Licharew (5, p. 158) states: "K. Novik described *Schwagerina carbonica* Novik even from the horizon $C_2^2$ [Middle Carboniferous] of the Donetz basin, but the correctness of their generic determination must be verified. See K. Novik: Ueber einige Vertreter der Foraminiferen des Carbons des Donetzbeckens etc. Sci. Mag. of the Geological Catheder of Dhnepropetrovsk, 1927 (in Russian)."

[5] This species was named by Ehrenberg in 1842 (*K. preuss. Akad. Wiss. Berlin, Verh.*,

of *Schwagerina*, came from Pinega, Archangel, Russia. They are short and robust, as are most of the forms which are now generally referred to *Schwagerina*, but very little information is available in regard to their internal structures. Our concept of the genus is in reality based on specimens from the mouth of Belaja River at Indiga Bay, Archangel, Russia, which were well described and illustrated by Möller (6) and referred to Ehrenberg's species. It is not at all certain that Möller's specimens are conspecific with Ehrenberg's types but they may well be congeneric—at any rate, there is no good reason to believe that they are not. Professor C. O. Dunbar has recently told us that he is restudying part of Ehrenberg's type specimens and is making thin-sections of them. At least, until the results of his work are available, it will be best to use the generic term in its generally accepted sense.

SCHWAGERINA FOSTERI Thompson and Miller, n. sp.

Plate 79, figures 1–7

*Schwagerina* sp. FOSTER, *1923*, West China Border Research Soc., Jour., 1922–1923, p. 50.

Shell of medium size for the genus, short, very highly inflated, and subspherical at late maturity. Poles very bluntly pointed. Lateral slopes convex. Mature specimens consist of about nine volutions and they are about 6.0 mm. in length and 4.0 to 4.7 mm. in width. The form ratio of mature specimens is 1:1.3 to 1:1.6. The general profile of the shell changes very markedly with the growth of the individual. In specimens of two or three volutions the shell is slender and the poles are very sharply pointed. Beyond the third volution the relative lengthening of the axis decreases rapidly. The form ratio is 1:3.0 to 1:3.6 for the third volution, 1:2.2 to 1:2.6 for the fifth volution, and 1:1.6 to 1:2.0 for the seventh volution.

Septa thin. They are composed of the downward deflection of the tectum of the spirotheca and of a lighter layer on the posterior side of the tectum which appears to wedge out between the tectum of the septa and the keriotheca of the spirotheca. This lighter portion may be a continuation of part of the keriotheca of the spirotheca, but it appears to be more dense than the keriotheca. In the seventh volution the septa are about 35 microns thick. The septal count for the first to the ninth volution of a typical specimen gives 8, 10, 13, 17, 17, 16, 16, 25, and 33. As can be seen from this count, the septa increase in number very slowly during the first seven volutions, but they become much more numerous in the eighth and ninth volutions. The septa are very narrowly and highly fluted throughout the length of the shell. A section tangential to the sixth volution (Pl. 79, fig. 3) shows that the septa are deeply fluted from top to bottom. In the young individual represented by figure 6 on plate 79, the width of the fluting is 160 microns at the top of the antetheca and 350 microns at the base of the antetheca.

The proloculum is essentially spherical. Its inside diameter measures 100 to 140 microns. The average diameter for six typical specimens is 125 microns. The inner three volutions are very tightly coiled; the height of the chambers increases rapidly in the fourth volution; and the outer volutions consist of very highly vaulted chambers. The heights of the chambers near the centers of the first to the ninth volutions measure about 26, 43, 60, 105, 225, 402, 560, 472, and 440 microns, respectively. During the eighth

p. 274, 1842) and the types were first illustrated by Ehrenberg in 1854 (*Mikrogeologie* [atlas], pl. 37, figs. X, C, 1–4).

and ninth volutions the shell becomes more tightly coiled.

In the inner three volutions the tunnel is low and narrow and is bordered by well defined low asymmetrical chomata. In the outer volutions no chomata are developed, and therefore the width of the tunnel can not be determined; however, the presence of a tunnel is evidenced by the failure of the septa to reach the spirotheca of the preceding volution. The tunnel appears to be low and narrow in the outer four volutions.

Spirotheca thick. It is composed of a tectum and a keriotheca. The alveoli are very coarse and in the seventh volution they are slightly more than 20 microns in diameter. There is a more or less wedge-shaped extension of the keriotheca down the anterior side of each septum. Typically the keriotheca is particularly thick along the central portion of the chambers and relatively thin near the anterior end of the chambers. Near the center of the chambers of the first to the eighth volutions, the thickness of the spirotheca measures 14, 24, 35, 48, 64, 85, 120, and 127 microns, respectively.

*Discussion.—Schwagerina fosteri* resembles rather closely *S. kansasensis* Beede and Kniker of the Neva limestone of Kansas and these two species are probably very closely related. However, *S. fosteri* is a much smaller species; the juvenarium of the two species is very similar but in the Chinese species the outer volutions are not as highly inflated; the septal count of the two species is markedly different; and the spirotheca of *S. kansasensis* is thinner than is that of *S. fosteri*. Also, the original illustrations of *S. kansasensis* indicate that in that species the septa are not as highly fluted as are those of *S. fosteri*. The measurements given by Lee for his species *S. tinvenkiangi* of the upper Taiyuan series of northern China agree very closely with those of *S. fosteri*, and these two forms may possibly be conspecific. As the sections of *S. tinvenkiangi* that have been figured by Lee are not centered and are not well oriented, adequate comparisons are not possible, but *S. fosteri* apparently contains more volutions, its shell expands more slowly at the end of the juvenarium, and its septa appear to be more highly fluted. *S. fosteri* resembles in general form *S. yabei* Staff of the Sosio beds of Sicily; however, the Sicilian species is larger and is more highly developed, its septa are not as highly or as narrowly fluted, its spirotheca is thinner, and its outer volutions are expanded more rapidly beyond the juvenarium.

*S. muongthensis* (Deprat) of Tonkin, French Indo-China, is similar to our species in general outline, but the internal structures of the two forms are quite different. The proloculum of the Indo-Chinese species is much larger; its juvenarium, which is not as tightly coiled, does not contain as many volutions and is shorter; the shell consists of fewer volutions; and the septa do not seem to be as strongly fluted. Also, *S.? dussaulti* (Deprat) from Yunnan, China, is somewhat similar to *S. fosteri*. That form was not well illustrated by Deprat but it appears to differ from *S. fosteri* particularly in that its shell is more elongate, its juvenarium is more rapidly expanded, its spirotheca is thinner, and its septa are more numerous.

*Types.*—Univ. Iowa, 1025–1028 (syntypes of *S. fosteri*); 1029 (figured specimen referred with question to *S. fosteri*); and 1030 (specimens figured as *Endothyra?* sp.).

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# THE PARADISE FORMATION AND ITS FAUNA[1]

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ABSTRACT

The Paradise formation is found in the southeast corner of Arizona and is the only known Tennesseean in the state. There are abundant fossils in limestone beds of the shale-limestone formation, some of which are well preserved. The fauna is well zoned and indicates that the formation is to be correlated with the St. Louis(?), Ste. Genevieve, lower Chester, and the Golconda of the middle Chester of the Mississippi Valley section. There are many relationships to the faunas of the Fayetteville and Pitkin of Oklahoma and much less pronounced features in common with the Batesville fauna. Forms which are represented by well preserved specimens are systematically discussed and thirteen new species or varieties are described and figured. Other important and representative fossils are also figured. A faunal chart gives the range of species in the Paradise formation, and indicates the now known range of many species in the standard Mississippian section. One hundred and fifty-five forms are listed of which one hundred and fifteen are identified specifically with various degrees of certainty.

The Paradise formation is of interest because of its Tennesseean fauna, whose zoning indicates that it is to be correlated with the St. Louis (?), Ste. Genevieve, and part of the Chester of the Mississippi Valley section. The formation is of slight extent in Arizona but it is part of an unusually thick Mississippian section in which there is no discernible break. It has not been possible to study the fauna of the whole section.

The material on which this study is based includes a rather complete collection of fossils made by Dr. A. A. Stoyanow during several brief excursions to the area, and extensive collections made by myself during the summer and fall of 1933. My collections were precisely referred to lithologic horizons which has made it possible to indicate rather detailed correlations with the Mississippi Valley section.

[1] This paper, in greater detail, was presented to the Department of Geology at the University of Arizona, May 14, 1934, as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The types of new species and varieties, as well as all other collections, are deposited in the geological museum of the University of Arizona at Tucson.

*Acknowledgments.* I am particularly indebted to Prof. A. A. Stoyanow for the free use of his collections and for many helpful criticisms and discussions. Profs. B. S. Butler, R. J. Leonard, and M. N. Short of the University of Arizona, and the late President C. C. O'Harra of the South Dakota School of Mines, have given freely of their time and encouragement. The people of the Portal-Paradise region facilitated the field work. Prof. Carey Croneis of the University of Chicago gave me access to the collections of the Walker museum. Dr. C. R. Keyes loaned rare literature from his private library.

## PREVIOUS WORK

Only two papers have been written concerning the Paradise formation: the original preliminary description of Stoyanow (49) who first discovered these rocks, and a second paper by Stoyanow (50) in which are embodied the more important observations of the present writer. The facts as known to Stoyanow led him in his original paper to correlate

the Paradise formation with the "late Meramecian and early Chesterian," a conclusion that is but slightly modified in this paper.

Most of the literature concerning the Upper Mississippian of the west consists of brief papers with short faunal lists, many of which are by Dr. G. H. Girty in numerous publications of the U. S. Geological Survey. A much more detailed discussion is found in a paper by Mansfield (26) in which Girty states:

> Thus, near the top of the Brazer we found at some localities a varied fauna which has a Chester facies and is comparable in many respects to the typical Chester faunas of the Mississippi Valley. Apparently holding a stratigraphic position below this Chester fauna, we found in places another interesting and rather well defined fauna which consists for the most part of small pelecypods and gastropods, and is comparable to the Spergen and Ste. Genevieve faunas of the Mississippian section (p. 68).
>
> In view of all the facts just recited, taken together with the stratigraphic position of this fauna in the Brazer below a very different fauna which shows marked Chester affinities, the fauna from station 3023 may tentatively be regarded as essentially of Spergen age. . . . I am inclined to believe that below the Chester horizon there is a considerable thickness of rocks in the Brazer in which these faunas appear more or less indiscriminately and which represents possibly other periods of time, but especially in its faunal aspects the Spergen and St. Louis . . . in the region . . . near Mackay, *Productella hirsutiformis* is found in the Brazer associated with a rather varied fauna, which, especially in its *Productella*-like forms, recalls the fauna of the Moorefield shale, though it lacks *Leiorhynchus carboniferum* and other noteworthy Moorefield species (p. 71).

The Brazer limestone thus contains faunules suggesting the presence of correlatives of the Spergen, St. Louis, Ste. Genevieve, and Chester of the Mississippi Valley, and certain beds yield a fauna recalling that of the Moorefield shale of Arkansas.

The following papers, classified by states, are representative of the literature dealing with western Upper Mississippian rocks.

*Montana.*—The Quadrant formation (1,300 feet) is partly of Pottsville age but some collections from a lower horizon suggest the Ste. Genevieve according to Girty (41). No collection is of characteristic Chester type.

*Idaho.*—Girty (57) concludes that the Mississippian of the Mackay region (7,000 feet) belongs mostly to the upper part of the system and that Moorefield and Mountain limestone facies are present.

*Utah.*—Collections from the Stockton region lead Girty (10) to conclude that the Deseret limestone (650 feet) fauna appears allied in some respects to that of the Moorefield, in others to that of the White Pine shale of Nevada, and represents the lower Brazer and some part of the Middle Mississippian. The Humbug formation (645 feet) yields a fauna allied to that of the earlier Brazer. The Great Blue limestone (3,600 feet) is tentatively referred to the lower Brazer and to the Middle Mississippian. The lower half of the Manning Canyon shale (total 1,140 feet) appears correlative with the Chester and the upper half is Pennsylvanian.

One of two collections made by Richardson (42) from the Brazer (800–1,400 feet, with probably unconformity at the top) is related to the fauna of the Moorefield shale, according to Girty. The other is not referred but appears to be of Spergen type.

Nolan (35) reports that in the Gold Hill Quadrangle, the Madison is overlain by the Woodman formation (1,000+ feet) whose fossils, according to Girty, indicate an Upper Mississippian age. The Ochre limestone (4,500 feet) is likewise assigned to the Upper Mississippian. The Manning Canyon shale (1,000+ feet) contains Pottsville fossils

but the lower part may represent high Upper Mississippian, as in the Oquirrh range.

Peck (38) describes *Ambolostoma baileyi* Peck, n. gen., n. sp., *Pentremites* cf. *P. conoideus* Hall, and *Pentremites* cf. *P. godoni* (Defrance) from the Brazer limestone of Utah.

*Nevada.*—Hewett's (21) collections from the Goodsprings Quadrangle were studied by Girty who assigns the Arrowhead (20 feet) and tentatively the Yellowstone (120 feet) members of the Monte Cristo limestone to the Middle Mississippian. The unconformably overlying Bird Spring formation (2,500 feet) is referred by Girty to the Pennsylvanian. In spite of the unconformity, the fauna of the lower 450 feet as listed by Girty appears to have a strong Upper Mississippian aspect.

The Eureka district, studied by Walcott (58), is badly faulted masking the stratigraphy. Girty (57, p. 28) in connection with the Mackay, Idaho, section states:

> . . . the White Pine shale, Diamond Peak quartzite, and the Lower Carboniferous [i.e. of the Eureka district] are all tentatively Upper Mississippian.

*California.*—In a paper by Knopf and Kirk (23) on the Inyo range, Girty states:

> . . . is an interesting and peculiar fauna of the Caney shale of Oklahoma, and the related but less well known fauna of the White Pine shale of Nevada. These faunas I refer to the Upper Mississippian.

Concerning a collection from a lower horizon of the White Pine shale (1,043 feet), Girty states:

> . . . presents a somewhat different facies, which may also be called Upper Mississippian. It may however be Lower Mississippian, but it does not show the familiar facies of the Madison limestone.

A number of representative papers (6, 7, 28, 46, 47) include discussions of the age of the usually much metamorphosed Carboniferous rocks of California. Mississippian fossils are listed but the lists do not give conclusive evidence as to whether Lower or Upper Mississippian rocks are present. There is some suggestion that both are present, and some distinctly European types of fossils are listed.

*Oregon.*—Packard (37) notes the presence of a typical Baird fauna in central Oregon with *Productus striatus* and *Productus giganteus.*

*Summary.*—The conclusions justified from a study of the papers referred to are as follows. The Upper Mississippian is widely represented in the Great Basin and adjoining areas, in places by great thicknesses of rocks. In general, limestones predominate in the eastern part of the Great Basin but shales are much more abundant farther west. Facies suggesting the Salem, St. Louis, Ste. Genevieve, and Chester are found at various localities though apparently all have been found together only in southeastern Idaho. There is also evidence that faunas of Moorefield and Caney type are present, the former being rather widely distributed. Mississippian rocks in Idaho, California, and Oregon yield fossils at certain localities which are distinctly of European type.

## DESCRIPTION OF THE PARADISE FORMATION

The type section of the Paradise formation, described by Stoyanow (49), lies a few miles east of the old mining camp of Paradise, Arizona. It may be reached by driving 10 miles west from Rodeo, New Mexico, to Portal, Arizona, then about 3 miles north on the San Simon road, from which point one must walk about a mile to the west.

Stoyanow characterizes the Paradise formation as follows:

> This (group) is composed of black and gray moderately thick and thin-bedded crystalline limestone, olive and yellow when weathered, alternating with sandstone, shale, oolite, cross-bedded calcareous sandstone, and arenaceous limestone. The preponderant color of this formation is distinctly yellow, so much so that when looked upon at a distance it appears as a yellow band between the dark beds of the underlying Escabrosa and the higher Naco. The thickness of the formation as measured by the writer is 134 feet.

During my field work considerable time was spent locating sections which had not been so strongly affected by the widespread faulting of the region. Normal faults are very common and are accompanied by structures which developed in the relatively weak Paradise formation because of its position between the massive Escabrosa and Naco limestones. During the folding or tilting of the rocks the bedding-plane adjustments were strongly concentrated in the incompetent Paradise formation. The effects now seen are shattering, crumpling, and bedding-plane faulting, especially at the upper and lower contacts. The outcrops from 10 to 12 miles north of Portal are satisfactory, however. The section at this locality, shown in Table 1, is a composite of two excellent partial sections correlated by means of the prominent oolitic limestone known as the main oolite or the Fifth member in this paper. This bed is persistent and may be recognized by its lithology and well defined zones of fossils. This composite section has none of the structural disadvantages mentioned, and its total thickness is somewhat greater than that of the type area where beds, mainly at the contacts, are cut out by faults dipping nearly parallel to the bedding. From the more complete information obtained from this section the Paradise formation is redefined as a lithologic mapping unit, composed of gray and black moderately thick and thin-bedded, fine-grained to coarsely crystalline limestone, the dark limestone olive and yellow when weathered, alternating with shale, cross-bedded sandy limestone, and oolite. The base of the formation is chosen at the first marked evidence of shallowing of the waters, where the moderately-bedded limestones overlying the typical Escabrosa give place to shale and thinner-bedded limestones carrying limestone conglomerates near their base. The lithologic base is not marked by a sharp change in the fauna, but the top of the formation is marked by a sharp change in both lithology and fauna, although the probable unconformity at the top is not evident except regionally. Paleontologically, the Paradise formation is characterized by a normal Upper Mississippian fauna whose zoning indicates that the time of deposition extended from St. Louis into the middle Chester. The thickness of the composite section is 195 feet. The thickness in the type area is 134 feet and in a less faulted area nearby the writer measured 153 feet (see Table 2). The differences in thickness of these sections are believed to be due mainly to structural causes.

The sections given in Tables 1 and 2 are characterized by the presence

of gray limestone, in places cross-bedded, in the First to Third members. The limestone beds of the Fifth to Seventh members are nearly black and the shales are gray or black. The Fifth member is characterized by the prominently oolitic nature of its massive black beds. The Eighth member, when exposed, may be recognized by its gray granular limestone beds.

*Table 1. Composite Section North-Northwest of Portal*

Section 10 miles north-northwest of Portal

| | Thickness feet |
|---|---|
| *Naco limestone* (Pennsylvanian) | |
| Contact, not faulted | |
| *Paradise formation* (Mississippian) | |
| *Eighth member* | |
| Shaly beds, mostly covered | 4 |
| Gray granular limestone | 2 |
| Shaly beds, mostly covered | 6 |
| Gray granular limestone | 2 |
| *Seventh member* | |
| Thin-bedded limestone and shale; *Archimedes*, *Polypora*, and *Spirifer pellaensis* var. *cavecreekensis* abundant | 6 |
| Massive black limestone | 3 |
| *Sixth member* | |
| Mostly covered shales | 8 |
| Massive black limestone | 2 |
| Shale | 7 |
| Gray sandy limestone | 2 |
| Shale with a little limestone | 10 |

Section 12 miles north-northwest of Portal

| | |
|---|---|
| *Naco limestone* (Pennsylvanian) | |
| *Paradise formation* (Mississippian) | |
| Contact and Sixth to Eighth members of the Paradise formation largely concealed. | |
| *Fifth member* | |
| Massive black oolitic limestone, poorly exposed at base; first *Archimedes* and *Camarophoria explanata* | 8 |
| *Fourth member* | |
| Massive black limestone | 5 |
| Mostly covered shale with thin beds of limestone, with *Stigmaria* sp. | 5 |
| *Third member* | |
| Massive black limestone with fragmentary mollusks | 5 |
| Shale with thin beds of limestone, mostly covered | 10 |
| Dark-gray sandy limestone, very fossiliferous | 4 |
| Mostly covered shaly limestone | 6 |
| *Second member* | |
| Gray limestone, thin-bedded near base, moderately-bedded with chert above, and capped by a massive bed of coarsely crystalline limestone with great numbers of *Dielasmoides bisinuatus* | 21 |
| *First member* | |
| Covered shaly beds | 20 |
| Gray moderately- and thin-bedded limestone with chert; one foot limestone conglomerate at base; no fossils | 10 |
| Poorly exposed shaly beds | 6 |
| Alternating thin- and moderately-bedded gray limestone with chert near middle and one foot limestone conglomerate near base; few fossils | 28 |
| Mostly covered shaly beds that grade downward into moderately-bedded gray limestone of St. Louis age | 15 |
| | 195 |
| Base of formation | |
| Unnamed moderately-bedded limestone of St. Louis age | |

*Table 2. Composite Section 3 Miles North of Portal*

First section

| | Thickness feet |
|---|---|
| *Naco limestone* (Pennsylvanian) | |
| Contact, not faulted | |
| *Paradise formation* (Mississippian) | |
| *Eighth member* | |
| Concealed shaly beds | 2 |
| Gray limestone | 2 |
| Shales, mostly covered | 4 |
| *Seventh member* | |
| Massive bed black limestone | 2 |
| Thin-bedded dark limestone, rich *Archimedes* zone | 6 |
| Massive bed black limestone | 2 |

Second section

| | |
|---|---|
| *Naco limestone* (Pennsylvanian) | |
| Fault contact | |
| *Paradise formation* (Mississippian) | |
| *Seventh* (?) *member* | |
| Brecciated buff limestone | 2 ft. |
| Sill of gray-green igneous rock | 4 ft. |
| Massive bed black limestone | 2 ft. |
| *Sixth member* | |
| Gray and black shale | 1.5 |

| | |
|---|---|
| Moderately-bedded dark limestone; plants at base | 3.5 |
| Deeply weathered limy shale | 2.5 |
| Massive black limestone with crenulated chert | 3 |
| Black and gray thin to moderately-bedded limestone | 4.5 |
| Black shale with a few thin limestone beds | 8.5 |
| Mostly limestone, thin-bedded at the base, crushed in the middle, and massive at the top; plants | 4 |
| Shale and thin-bedded black limestone | 4.5 |
| Crushed gray limestone | 2 |
| Black and gray shale with thin-bedded limestone in the middle | 8.5 |
| *Fifth member* | |
| Massive black oolitic limestone; first *Archimedes* and *Camarophoria explanata* | 9 |
| *Fourth member* | |
| Massive to thin-bedded black limestone | 4.5 |
| Black and gray shale with several beds of black limestone; badly crumpled, thickness not true | 43.5 |
| *Second and third members* | |
| Gray-green shale with black shaly limestone near middle | 7.5 |
| Gray limy shale with thin- to moderately-bedded dark limestone at top | 9 |
| Alternating massive cross-bedded sandy limestone and thin beds of shale | 17.5 |
| Crumpled shaly gouge | 1.5 |
| | 153.0 |
| Unnamed formation | |

## STRATIGRAPHIC RELATIONS OF THE PARADISE FORMATION

The Paradise formation has been certainly recognized only in a long foothill ridge extending northwesterly from Portal, Arizona, for a distance of about 13 miles (fig. 1). The formation appears to be restricted in Arizona to the Chiricahua Mountains, in which the studied area is located. It is absent at Bisbee to the southwest, in the Dragoon Mountains to the west, and in the Dos Cabezas Mountains, near the town of the same name, to the northwest. I have not visited the Morenci district but study of Lindgren's (24) report indicates that the formation is probably absent there. A few fossils collected by Dr. Carl Lausen in the Whetstone Mountains northwest of Tombstone suggest forms from the Paradise formation but I have not seen the formation in that range. The formation is probably present east of Portal in New Mexico in the isolated exposures of Paleozoic rocks, but there has been no opportunity to check this point by field work.

*Generalized stratigraphic column of the Mississippian at Portal*

| | Thickness feet |
|---|---|
| PENNSYLVANIAN | |
| *Naco limestone* | |
| Unconformity (indicated by regional relations) | |
| TENNESSEEAN | |
| *Paradise formation* | 195 |
| Unnamed moderately bedded limestone with St. Louis fossils at the top | 150 |
| WAVERLYAN | |
| *Escabrosa limestone*, massive limestone with abundant horn corals and *Spirifer centronatus* | 531 |
| *Escabrosa limestone*, moderately-bedded gray limestone with little shale; *Spirifer gregeri* | 120 |
| WAVERLYAN (?) | |
| Unnamed formation of three unfossiliferous members: | |
| Top, thin-bedded limestone alternating with thin beds of shale | 120 |
| Middle, black fissile shale | 56 |
| Base, beds like those of top member | 124 |
| Total | 1296 |
| Base of Mississippian (?) | |
| DEVONIAN | |
| *Martin limestone* | |

Lithologically this section shows a gradual change from muddy-water deposition near the base to a maximum of clear-water deposition during Escabrosa time, followed by

shallowing of the waters and the introduction of clastic sediment during Paradise time. I have not been able to recognize any evidence of an important unconformity at any place in this section. The introduction of shales at the base of the Paradise formation is not accompanied by a marked change in fauna, though it should be stated that the lower beds of the formation are very sparingly fossiliferous. The top of the Paradise formation, however, is marked by a sharp change in fauna and lithology and there is regional evidence of an unconformity at this horizon.

The thickness of the Mississippian at Portal is 1,296 feet, at Pine, in central Arizona, 80 feet (Stoyanow, A. A., personal communication), and in the Grand Canyon 650 feet. The thinnest section, that near Pine, is in the region of the barrier postulated by Ransome (40), and described by Stoyanow (49, p. 314) as Mazatzal land. This positive area is evidenced during Paleozoic time by the marked differences between the sections to the north and the south, and by the greater proportion of clastics in the sediments of the Mazatzal region. During the Mississippian period this region was submerged, and the thinness of the Mississippian rocks near Pine is hence probably due to a period of erosion in post-Redwall pre-Pennsylvanian time. This period of erosion apparently removed increasingly great thicknesses of Mississippian rocks toward the domed area of central Arizona. Such erosion explains the overlapping position of the Pennsylvanian which rests on the Chester at Portal but on the lower Redwall at Pine.

FIG. 1—Index Map of Arizona

## PALEOGEOGRAPHY

The erosion marked by the unconformity just described has obliterated all definite evidence of the original extent of the Paradise formation. The fauna of the Great Basin Upper Mississippian formations indicates connection to both the Arkansas-Oklahoma and Illinois-Kentucky basins of deposition, while the presence of typical Upper Mississippian fossils, together with some peculiarly Batesville types, in the Paradise formation indicates that the latter region was similarly connected. Hence it is probable that the seas of the Great Basin were connected with the Paradise sea and thence eastward across New Mexico and Texas to the central Mississippi Valley.

Such a connection is shown by Schuchert (45).

## FAUNAL HORIZONS AND THEIR CORRELATION

The faunal zones recognized in the Paradise formation indicate that the formation represents the time from St. Louis to Golconda of the middle Chester, inclusive. For convenience, the Paradise formation is divided into eight members. Brief discussions of the faunas of the beds underlying and overlying the Paradise formation are given along with the discussion of faunal horizons of the Paradise formation itself.

*Unnamed limestone below the Paradise formation.*—The beds immediately below the Paradise formation yield the following:

*Fauna of Limestone below the Paradise Formation*

Corals, a small *Triplophyllum*, etc.
Crinoid stem plates
*Archaeocidaris* spines and plates
*Cystodictya* sp.
*Dichotrypa elegans* Ulrich (St. Louis group)
*Fenestella tenax* Ulrich
*Chonetes* sp.
"*Productus*" *indianensis*, large variety
"*Productus*" *marginicinctus* Prout (St. Louis limestone)
"*Productus*" *scitulus* Meek and Worthen (St. Louis limestone)
*Echinoconchus biseriatus* (Hall)
*Dielasma formosum* (Hall)
*Dielasma* aff. *D. sinuatum* Weller (Warsaw to St. Louis)
*Dielasma* sp.
*Spiriferina* sp.
*Spirifer bifurcatus* Hall
*Reticularia setigera* (Hall)
*Eumetria verneuilana* (Hall)
*Athyris* sp.
*Composita* sp.
*Cliothyridina hirsuta* (Hall) (Warsaw to Ste. Genevieve)
*Platyceras acutirostris* (Hall) (Salem, Ste. Genevieve)
*Euomphalus spergenense* var. *planorbiforme* Hall (Spergen)

It will be seen at once that the listed species are predominantly of St. Louis type. The presence of *Dichotrypa elegans*, "*Productus*" *marginicinctus*, *P. scitulus*, *Dielasmoides bisinuatus*, and abundant *Archaeocidaris* spines is especially noteworthy. None of the typical Warsaw and Spergen species, such as "*Productus*" *magnus*, *Spirifer lateralis*, *S. tenuicostatus*, *S. washingtonensis*, and *Brachythyris subcardiformis*, have been found. The apparent absence of *Lithostrotion canadense* is perhaps not important for there may have been some kind of barrier that prevented migration of this coral into the Arizona region. In view of these facts, the beds below the Paradise formation are correlated with the St. Louis but there is a possibility that a fauna like that listed may yet be found in the Ste. Genevieve.

*First member of the Paradise formation.*—The base of the Paradise formation is chosen at the top of the last discussed limestones where marked shallowing of the waters is evidenced by the appearance of shales and fragmental limestones. The 79 feet of beds of the First member are about equally divided between medium-bedded gray limestone and poorly exposed shale with thin beds of limestone. The whole is unfossiliferous but the following forms were collected: *Rhombopora wortheni* Ulrich ("Keokuk(?)," "St. Louis group or lower Kaskaskia"), *Tabulipora tuberculata* (Prout)(?), *Fenestella* sp., *Modiola illinoiensis* Worthen(?), crinoid stems, and shark teeth. This meager fauna is not diag-

nostic. The beds below the First member are St. Louis in age while those above are definitely Ste. Genevieve, hence the member may be assigned to either from the information now available. It is tentatively correlated with the St. Louis.

*Second member of the Paradise formation.*—The beds of the Second member comprise thin- to medium-bedded gray limestones capped by a massive coarsely crystalline bed of limestone bearing great numbers of *Dielasmoides bisinuatus* Weller. The member yields the following forms:

*Fauna of the Second Member of the Paradise Formation*

Crinoid stem plates
*Fenestella tenax* Ulrich
*Rhipidomella dubia* (Hall)
*Chonetes* sp.
*Linoproductus ovatus* (Hall)
*Camarotoechia mutata* (Hall)
*Pugnoides ottumwa* (White)?
*Dielasmoides bisinuatus* Weller
*Dielasma formosum* (Hall)?
*Spirifer bifurcatus* Hall
*Composita* cf. *C. lewisensis* Weller
*Composita trinuclea* (Hall)
*Cliothyridina* sp.
*Ambocoelia* sp.
*Modiola illinoiensis* Worthen
*Griffithides* sp.

Species of value in correlation are *Rhipidomella dubia*, *Camarotoechia mutata*, and *Spirifer bifurcatus*, which do not extend above the Ste. Genevieve; *Modiola illinoiensis* which is not certainly known in beds older than the Ste. Genevieve; the specimens identified as *Pugnoides ottumwa*(?) which are almost certainly that species, being queried only because of the absence of good brachial valves; and *Dielasmoides bisinuatus* which has been recorded by Weller from the St. Louis(?) oolite but is found in both St. Louis and Ste. Genevieve beds in the Paradise section.

From the faunal evidence the Second member is correlated with the Ste. Genevieve. If the form *Pugnoides ottumwa*(?) is actually that species, as believed, there can be no question concerning the age of these beds.

*Third member of the Paradise formation.*—These beds include 6 feet of shaly strata at the base, followed by gray sandy limestone 4 feet thick, which is overlain in turn by 10 feet of poorly exposed shaly beds, and capped by a 5-foot bed of black limestone bearing abundant but fragmentary mollusks. A fairly large fauna, obtained mostly from the lower limestone bed, is listed, but a much greater number of species is undoubtedly present whose identification awaits the finding of better specimens than the member ordinarily yields. The faunal list follows:

*Fauna of the Third Member of the Paradise Formation*

Crinoid stem plates
*Batostomella*? sp.
*Cystodictya* sp.
*Rhombopora* cf. *R. tenuirama* Ulrich
*Rhombopora wortheni* Ulrich
*Streblotrypa* sp.
*Fenestella* cf. *F. serratula* Ulrich
*Fenestella tenax* Ulrich
*Polypora* sp.
*Orthotetes* cf. *O. keokuk* (Hall)
*Productus elegans* (Norwood and Pratten)?
*Linoproductus ovatus* (Hall)
*Echinoconchus biseriatus* (Hall)
*Pugnoides ottumwa* (White)?
*Dielasmoides bisinuatus* Weller, rare.
*Dielasma formosum* (Hall)?
*Girtyella brevilobata* (Swallow)
*Spirifer bifurcata* Hall
*Spirifer leidyi* Norwood and Pratten
*Spirifer pellaensis* Weller
*Eumetria verneuilana* (Hall)
*Composita* sp.
*Sanguinolites* sp.

*Edmondia* cf. *E. fountainensis* Weller
*Edmondia genevievensis* Weller
*Edmondia* sp.
*Nucula illinoisensis* Worthen
*Leda curta* Meek and Worthen
*Yoldia* sp.
*Sulcatipinna?* sp.
*Leptodesma robustum* Girty
*Leptodesma* aff. *L. carboniferum* Girty
*Modiola illinoiensis* Worthen
*Myalina congeneris* Walcott
*Myalina monroensis* Worthen
*Schizodus* cf. *S. batesvillensis* Weller
*Schizodus depressus* Worthen
*Streblopteria simpliciformis* Girty, and variety
*Deltopecten monroensis* (Worthen), and variety
*Bellerophon sublaevis* Hall
*Bucanopsis monroensis* (Weller)
*Euphemus lentiformis* Weller, and variety
*Straparollus similis* var. *plenus* Meek and Worthen
*Straparollus* sp.
*Strophostylus splendens* Girty
*Callonema?*
Numerous indeterminable pelecypods and gastropods
*Stroboceras* sp.
*Griffithides* sp.

Of the brachiopods, the rare specimens of *Dielasmoides bisinuatus* mark its last appearance in the Paradise formation; *Girtyella brevilobata* and *Spirifer leidyi* have not been recorded from horizons older than the Ste. Genevieve; *Echinoconchus biseriatus* has not been found higher than the Ste. Genevieve and *Spirifer pellaensis* is typically Ste. Genevieve, though recorded from both higher and lower beds by Weller. Of the mollusks, *Myalina monroensis*, *Edmondia genevievensis*, *Leda curta*, *Straparollus similis* var. *planus*, *Bucanopsis monroensis*, and *Euphemus lentiformis* are restricted to the Ste. Genevieve as far as known, excepting *E. genevievensis* which extends into the Chester portion of the Paradise formation; *Modiola illinoiensis*, *Schizodus depressus*, and *Nucula illinoisensis* are found in both the Ste. Genevieve and Chester. The nautilid *Stroboceras* sp. is very much like the form figured by Weller (66, p. 263) from the Ste. Genevieve. Types which find their relationships in the Batesville fauna include *Leptodesma robustum*, *L.* aff. *L. carboniferum*, the Batesville type of *Modiola illinoiensis*, and *Strophostylus splendens*.

From the fossil evidence it is concluded that the Third member is Ste. Genevieve in age, the only other possibility being a correlation with the lower Chester, which beds have not yielded a fauna of this type. In general the fauna closely resembles that described by Weller (66) from the Ste. Genevieve. It is similar to the fauna of the Batesville (16), and recalls the Spergen type of fauna listed by Girty (26) from the Brazer limestone.

*Fourth member of the Paradise formation.*—This member is one of the most fossiliferous parts of the Paradise formation, though less so than the overlying main oolite. It comprises about 14 feet of shales and thin-bedded limestones with a massive bed of black limestone near the middle. This member is badly crumpled in the section of Table 2. The fauna includes the following forms obtained mostly from the black limestone mentioned. Forms present in very rich though narrow zones are indicated by an asterisk.

*Fauna of the Fourth Member of the Paradise Formation*

Crinoid plates
*Fenestella tenax* Ulrich
*Orthotetes kaskaskiensis* (McChesney)?
*Orthotetes subglobosus* var. *batesvillensis* Girty
**Chonetes oklahomensis* Snider
*Buxtonia arkansansus* (Girty)

**Productus elegans* Norwood and Pratten
*Productus fasciculatus* McChesney?
**Linoproductus ovatus* (Hall)
*"Productus"* sp.
*Echinoconchus rodeoensis* Hernon, n. sp.
**Camarotoechia purduei* Girty?
**Spirifer arizonensis* Hernon, n. sp.
*Spirifer bifurcatus* Hall
*Spirifer leidyi* Norwood and Pratten
*Spirifer* sp.
*Eumetria vera* (Hall)
*Eumetria verneuilana* (Hall)
*Composita laevis* Weller
**Composita* cf. *C. ozarkana* Mather
**Composita deltoides* Hernon, n. sp.
*Composita trinuclea* (Hall)
*Composita* sp.
*Cliothyridina sublamellosa* (Hall)
*Pterinopecten* sp.
*Griffithides* sp.
Fish spines.
Plant, *Stigmaria* sp.

This fauna is decidedly Chester in its general aspect and includes several species which are peculiar to the Batesville sandstone. It is particularly characterized by the absence of *Archimedes* and other Bryozoa which are abundant in the overlying main oolite, a bed of Golconda age. The position of this member below middle Chester beds, together with the presence of an abundant species of *Chonetes* and *Camarotechia purduei*? and the absence of *Archimedes* and *Camarophoria explanata*, fix the age of the member as lower Chester.

*Fifth member of the Paradise formation.*—The Fifth member is a bed of black massive oolitic limestone from 5 to 9 feet in thickness known as the main oolite in this paper. The fauna is extensive both in number of species and individuals. Several prominent zones bear great numbers of Bryozoa (especially the genus *Archimedes*), brachiopods, and pelecypods. The faunal list follows with the forms present in rich zones marked by an asterisk.

*Fauna of the Fifth Member of the Paradise Formation*

*Pentremites* sp.
Crinoid plates
*Tabulipora* sp.
**Tabulipora tuberculata* (Prout)
*Cystodictya* sp.
*Glyptopora*? sp.
*Rhombopora* sp.
*Fenestella* cf. *F. morrowensis* Mather
*Fenestella multispinosa* Ulrich
*Fenestella tenax* Ulrich
**Archimedes confertus* Ulrich
**Archimedes invaginatus* Ulrich
**Archimedes proutanus* Ulrich
*Polypora cestriensis* Ulrich
*Phyllopora portalensis* Hernon, n. sp.
*Orthotetes kaskaskiensis* (McChesney)
**Chonetes oklahomensis* Snider
**Productus elegans* Norwood and Pratten and variety
*Productus fasciculatus* McChesney?
*"Productus" inflatus* McChesney
*"Productus"* sp.
*Buxtonia arizonensis* Hernon, n. sp.?
*Buxtonia arkansanus* Girty?
*Linoproductus ovatus* (Hall)
**Echinoconchus rodeoensis* Hernon, n. sp.
**Camarophoria explanata* (McChesney)
*Dielasma shumardanum* (Miller)
*Dielasma* sp.
*Girtyella brevilobata* (Swallow)?
**Girtyella indianensis* (Girty)
**Girtyella indianensis* var. *exporrecta* (Girty)
*Spiriferina transversa* (McChesney)
*Spirifer arizonensis* Hernon, n. sp.
*Spirifer bifurcatus* Hall
*Spirifer leidyi* Norwood and Pratten
*Spirifer* sp.
**Brachythyris chesterensis* Butts
**Reticularia setigera* (Hall)
**Eumetria vera* (Hall)
**Eumetria verneuilana* (Hall)
*Composita laevis* Weller
**Composita* cf. *C. ozarkana* Mather
*Composita* sp.
*Composita trinuclea* (Hall)
**Composita deltoides* Hernon, n. sp.
**Cliothyridina sublamellosa* (Hall)
*Edmondia* cf. *E. crassa* Girty
*Edmondia* cf. *E. crassa* var. *symmetrica* Girty
**Edmondia genevievensis* Weller
*Nucula* cf. *N. randolphensis* Weller
*Nucula* cf. *N. platynotus* Weller
*Parallelodon illinoisensis* Weller?
*Parallelodon minima* (Worthen)
*Leptodesma robustum* Girty?
*Modiola fountainensis* Weller
*Modiola illinoiensis* Worthen?
*Myalina angulata* Meek and Worthen
*Schizodus* cf. *S. brannerianus* Girty
*Schizodus chesterensis* Meek and Worthen
*Streblopteria* sp.
**Deltopecten monroensis* (Worthen)

*Deltopecten* cf. *D. tahlequahensis* Snider
*Pterinopecten* sp.
*Paleolima* cf. *P. chesterensis* (Worthen)
*Levidentalium* sp.
*Bucanopsis* sp.
*Euphemus* sp.
*Naticopsis* aff. *N. waterlooensis* Weller
*Orthonychia striatulus* var. *portalensis* n. var.
*Platyceras* sp., large species
*Cycloceras randolphensis* (Worthen)
Coiled nautiloid
*Griffithides* sp.
*Paraparchites*? sp.
Shark teeth

This collection is typically Chester in its facies and the beds in which it is found can be closely correlated with the Illinois section. Weller (67, p. 186) has summarized the characteristics of the Golconda and the pertinent points are: The first introduction and abundant occurrence of *Camarophoria explanata*, the common occurrence of . . . mollusks . . . which are unknown in any other Chester fauna, [and] the great increase of the genus *Archimedes*. These characteristics are well shown by the Fifth member. *Camarophoria explanata* and *Archimedes* appear for the first time at the base of the oolite, and abundant poorly preserved mollusks are found in the oolite and in a thin gray sandy limestone at the top of the member. There can be little doubt of the Golconda age of the Fifth member. It is noteworthy that the oolite contains a molluscan fauna of Salem type in addition to the brachiopods and bryozoans.

*Sixth member of the Paradise formation.*—This member comprises shales with limestone beds aggregating a thickness of 29 to 38 feet. The fauna is much like that of the Fifth and Seventh members. It is of interest that plants are found near the middle and the top of the member in close association with fenestellid bryozoans and small thin-shelled brachiopods.

*Fauna of the Sixth Member of the Paradise Formation*

Corals
*Pentremites* fragments
Crinoid plates
*Batostomella spinulosa* Ulrich
*Tabulipora* sp.
*Eridopora* sp.
*Rhombopora* cf. *R. decipiens* Ulrich
*Streblotrypa nicklesi* Ulrich
*Streblotrypa nicklesi* var. *occidentalis* Hernon, n. var.
*Fenestella* sp.
*Fenestella tenax* Ulrich
*Archimedes confertus* Ulrich
*Archimedes invaginatus* Ulrich
*Archimedes lativolvis* Ulrich?
*Archimedes* cf. *A. proutanus* Ulrich
*Archimedes* sp.
*Archimedes* cf. *A. terebriformis* Ulrich
*Polypora* sp.
*Thamniscus furcillatus* Ulrich
*Septopora cestriensis* Prout
*Septopora decipiens* var. *paradisensis* Hernon, n. var.
*Orthotetes kaskaskiensis* (McChesney)
*Chonetes oklahomensis* Snider
*Productus elegans* Norwood and Pratten
*Productus fasciculatus* McChesney?
*Linoproductus ovatus* (Hall)
*Buxtonia arizonensis* Hernon, n. sp.?
*Camarophoria explanata* (McChesney)
*Dielasma formosum* Hall?
*Dielasma illinoisense* Weller?
*Dielasma shumardanum* (Miller)
*Dielasma* sp.
*Girtyella indianensis* (Girty)
*Girtyella indianensis* var. *exporrecta* (Girty)
*Spiriferina spinosa* Norwood and Pratten
*Spirifer leidyi* Norwood and Pratten
*Spirifer pellaensis* var. *cavecreekensis* Hernon, n. var.
*Spirifer* sp.
*Reticularia setigera* (Hall)
*Eumetria vera* (Hall)
*Eumetria verneuilana* (Hall)
*Composita* cf. *C. ozarkana* Mather
*Composita* sp.
*Cliothyridina sublamellosa* (Hall)
*Deltopecten* cf. *D. tahlequahensis* Snider
Indeterminable gastropods
*Cycloceras* sp.
Shark teeth
Plant remains

Some forms are listed here for the first time but this may be due in some

cases to collecting conditions. However, *Archimedes lativolvis?*, *Spiriferina spinosa*, and *Spirifer pellaensis* var. *idahoensis*, n. var. really appear for the first time and become very abundant in the succeeding member. The age of the Sixth member is Golconda since beds of that age inclose it.

*Seventh member of the Paradise formation.*—This member consists of shale, dark thin-bedded highly fossiliferous limestones, and one massive bed of black limestone, the whole about 9 feet in thickness. The member, like that above it, is covered in many places by talus, is highly crumpled, or is faulted out. It may be readily recognized by its stratigraphic position and lithology and by the abundance of *Archimedes lativolvis* and discrete valves of *Spirifer pellaensis* var. *cavecreekensis*, n. var. *Buxtonia arizonensis*, n. sp. is very abundant in the massive limestone bed. The faunal list follows with forms present in prominent zones indicated by an asterisk.

*Fauna of the Seventh Member of the Paradise Formation*

Horn coral
*Pentremites*, several species
Crinoid plates
*Eridopora macrostoma* Ulrich
*Eridopora occidentalis* Hernon, n. sp.
*Eridopora* sp.
*Batostomella* cf. *B. nitidula* Ulrich
*Batostomella spinulosa* Ulrich
*Tabulipora paradisensis* Hernon, n. sp.
*Tabulipora* sp.
*Rhombopora persimilis* Ulrich
*Rhombopora* sp.
*Streblotrypa nicklesi* Ulrich
*Streblotrypa nicklesi* var. *occidentalis* Hernon, n. var.
**Fenestella tenax* Ulrich
*Fenestella* sp.
**Archimedes confertus* Ulrich
*Archimedes* cf. *A. intermedius* Ulrich
**Archimedes invaginatus* Ulrich
**Archimedes lativolvis* Ulrich
*Archimedes proutanus* Ulrich
**Polypora cestriensis* Ulrich, and variety
*Polypora* cf. *P. spinulifera* Ulrich
**Septopora cestriensis* Prout
*Septopora decipiens* var. *paradisensis* Hernon, n. var.
*Septopora subquadrans* Ulrich
*Orthotetes kaskaskiensis* (McChesney)
*Chonetes oklahomensis* Snider?
*Productus elegans* N. and P.
*Productus fasciculatus* McChesney?
"*Productus*" *inflatus* McChesney
"*Productus*" sp.
*Linoproductus ovatus* (Hall)
**Buxtonia arizonensis* Hernon, n. sp.
*Buxtonia arkansanus* (Girty)
*Echinoconchus rodeoensis* Hernon, n. sp.
*Eomarginifera* aff. *E. adairensis* (Drake)
**Camarophoria explanata* (McChesney)
*Dielasma illinoisense* Weller?
*Dielasma shumardanum* (Miller)
*Dielasma* sp.
*Girtyella brevilobata* (Swallow)
*Girtyella indianensis* (Girty)
**Spiriferina spinosa* Norwood and Pratten, and variety
**Spiriferina spinosa* var. *cochisensis* Hernon, n. var.
*Spiriferina transversa* (McChesney)
*Spirifer leidyi* Norwood and Pratten
**Spirifer pellaensis* var. *cavecreekensis* Hernon, n. var.
*Reticularia setigera* (Hall)
*Eumetria vera* (Hall)
*Eumetria verneuilana* (Hall)?
*Eumetria* sp.
*Composita laevis* Weller
**Composita* cf. *C. ozarkana* Mather
*Composita* sp.
*Cliothyridina sublamellosa* (Hall)
*Myalina angulata* Meek and Worthen
Poor specimens of turreted gastropods
*Griffithides* sp.
Shark teeth

Of the foregoing, *Archimedes lativolvis*, the genus *Eridopora*, "*Productus*" *inflatus*, *Buxtonia arizonensis*, and *Spirifer pellaensis* var. *cavecreekensis*, n. var., are of interest because of their first appearance, at least in great numbers. The abundant occurrence of *Archimedes lativolvis*, restricted to the Golconda according to Weller (67, p. 186), and the general facies of this fauna requires cor-

relation with the Golconda of the Illinois section. The crinoids and blastoids are not determinable.

*Eighth member of the Paradise formation.*—This member is made up of shales with two beds of gray granular limestone aggregating a thickness of about 10 feet. The limestone yields abundant specimens of *Linoproductus ovatus* (Hall) and a few of *Eumetria vera* (Hall), *Rhynchopora?* sp., and *Deltopecten* sp. This meager fauna cannot be satisfactorily interpreted except to say that it is probably Chester. Since there is no discernible break between this member and the preceding one, it is best correlated with the Golconda or the succeeding Glen Dean. The limestone contrasts with that underlying the member because of its gray color. The absence of such forms as *Camarophoria explanata*, *Spiriferina spinosa*, and the new variety *Spirifer pellaensis* var. *idahoensis* is noteworthy, but probably of no particular significance, since these forms are usually restricted to narrow zones.

*The overlying Pennsylvanian limestone.*—The Eighth member of the Paradise formation is overlain by dark-gray fine-grained Naco limestone which yields the following species at the base.

*Fauna of Basal Beds of the Naco Limestone*

*Orthotetes?* sp.
*Schizophoria texana* Girty
*Chonetes* sp.
"*Productus*" cf. *P. coloradoensis* Girty
"*Productus*" sp.
*Spirifer occidentalis* Girty
*Pseudomonotis* sp., large species
*Nucula ventricosa* Hall
*Deltopecten* sp.
Undetermined pelecypod
*Bellerophon crassus* Meek and Worthen

A few feet higher are reefs of *Chaetetes milleporaceous* Milne-Edwards and Haime. This fauna is Pennsylvanian in age.

The Mississippian does not pass into the Pennsylvanian without break and the writer has found no evidence either in the Paradise formation or in the Naco limestone of a fauna of Morrow type. That such a fauna may have been present in beds removed by the post-Paradise pre-Naco period of erosion is entirely possible. The forms listed by Stoyanow (49) from the Paradise formation include *Pustula nebraskensis*, *Productus cora*, and *P. nanus*, but he (personal communication) later determined that these species came from the Naco limestone. They are not represented in my collections from the Paradise formation.

*Batesville elements in the Paradise formation.*—The Paradise formation yields in certain horizons a few species or types of species that are believed to be identical with species peculiar to the Batesville sandstone of Arkansas. There are, moreover, many relationships between the fauna of the upper Paradise formation and the fauna of the Oklahoma-Arkansas Chester as made known by Girty (14) and Snider (48). Forms that are peculiar to or characteristic of the Batesville and that are found in the Paradise formation in association with typical Illinois fossils are as follows.

*Characteristic Batesville Fossils in the Paradise Formation*

*Orthotetes subglobosus* var. *batesvillensis*
*Buxtonia arkansanus*
*Camarotoechia purduei?* and varieties

*Leptodesma robustum*
*L.* aff. *L. carboniferum*
*Myalina monroensis* parallelogram type
*Modiola illinoiensis* Batesville type
*Schizodus* cf. *S. brannerianus*
*Edmondia* cf. *E. crassa*
*Strophostylus splendens*

The absence of the cephalopods and the *Caneyellas* of the Batesville in the Paradise formation is noteworthy, though these fossils are not as abundant in the Batesville as in the Moorefield shale.

Most of the forms listed occur in the Third and Fourth members of the Paradise formation, the combined fauna of which has the same general facies as the Batesville. About 40 of the 71 species of these members are identical with, or closely related to, Batesville forms. The Arkansas formation and the Paradise beds mentioned both lack the genus *Archimedes*, and both underlie beds of middle Chester age. The large *Rhipidomella* suggests *R. arkansana* of the Moorefield shale but it is specifically distinct.

While the evidence is not strong enough to warrant definite conclusions, especially since the Batesville forms listed are mostly mollusks, yet it seems legitimate to tentatively correlate the Third and Fourth members of the Paradise formation with the Batesville sandstone of Arkansas.

Because the Batesville forms listed are accompanied by a much stronger facies of the Illinois type, it is possible to suggest a correlation of the Batesville sandstone with the Illinois section. The Third member is of Ste.

*Correlation Table*

<table>
<tr><th>Mississippi Valley</th><th>Paradise formation, etc.</th><th>Arkansas-Oklahoma</th><th>Brazer limestone, S.E. Idaho</th></tr>
<tr><td>Kinkaid<br>Clore<br>Menard<br>Vienna</td><td>Unconformity</td><td rowspan="2">Pitkin</td><td rowspan="5">Chester type fauna</td></tr>
<tr><td>Glen Dean<br>Golconda</td><td>?Member 8<br>Members 5, 6, 7</td><td>Fayetteville</td></tr>
<tr><td>Paint Creek<br>Renault</td><td>Member 4</td><td rowspan="2">Batesville</td></tr>
<tr><td rowspan="2">Ste. Genevieve</td><td>Member 3</td></tr>
<tr><td>Member 2</td><td rowspan="3">Moorefield</td><td>Ste. Genevieve type</td></tr>
<tr><td>St. Louis</td><td>?Member 1<br>Unnamed fm.</td><td>St. Louis type</td></tr>
<tr><td>Spergen</td><td>?Unnamed fm.</td><td>Spergen type</td></tr>
<tr><td>Warsaw</td><td>?Unnamed fm.</td><td>?</td><td></td></tr>
<tr><td></td><td>Typical Escabrosa</td><td></td><td></td></tr>
</table>

THE PARADISE FAUNA AND RANGE OF SPECIES

| | Members of Paradise Formation | | | | | | | | Warsaw | Salem | St. Louis | Ste. Genev. | Chester | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | Grp. | L. | M. | U. |
| Corals | — | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — |
| Crinoids | × | × | × | × | × | × | × | — | — | — | — | — | — | — | — | — |
| *Pentremites* | — | — | — | — | × | × | × | — | — | — | — | — | — | — | — | — |
| *Archimedes confertus* | — | — | — | — | × | × | × | — | — | — | — | — | — | × | × | — |
| *Archimedes* cf. *A. intermedius* | — | — | — | — | — | — | × | — | — | — | — | — | × | — | × | × |
| *Archimedes invaginatus* | — | — | — | — | × | × | × | — | — | — | — | — | × | — | × | — |
| *Archimedes lativolvis* | — | — | — | — | — | ? | × | — | — | — | — | — | — | — | × | — |
| *Archimedes proutanus* | — | — | — | — | × | ? | ? | — | — | — | — | — | — | × | × | × |
| *Archimedes* cf. *A. teribriformis* | — | — | — | — | — | × | — | — | — | — | — | — | × | — | × | × |
| *Batostomella armata* | — | — | — | — | — | ? | — | — | — | — | — | — | — | — | — | — |
| *Batostomella* cf. *B. nitidula* | — | — | — | — | — | — | × | — | — | — | — | — | — | × | × | × |
| *Batostomella* sp. | — | × | × | — | — | — | × | — | — | — | — | — | — | — | — | — |
| *Batostomella spinulosa* | — | — | — | — | — | × | × | — | — | — | — | — | × | × | × | — |
| *Cystodictya* sp. | — | — | × | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Eridopora macrostoma?* | — | — | — | — | — | — | × | — | — | — | — | — | × | — | × | — |
| *Eridopora occidentalis* n. sp. | — | — | — | — | — | — | × | — | — | — | — | — | — | — | — | — |
| *Eridopora* sp. | — | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — |
| *Fenestella cestriensis* | — | ? | × | — | — | — | × | — | × | — | — | × | × | × | × | — |
| *Fenestella* cf. *F. morrowensis* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Fenestella multispinosa* | — | — | — | — | × | — | — | — | × | — | — | × | aff. | — | — | — |
| *Fenestella* cf. *F. serratula* | — | — | × | — | — | — | — | — | × | × | × | × | — | × | × | × |
| *Fenestella* sp. | × | × | × | — | × | × | × | — | — | — | — | — | — | — | — | — |
| *Fenestella tenax* | — | ? | × | × | × | × | × | — | × | × | — | × | — | × | × | × |
| *Glyptopora* sp. | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Phyllopora portalensis* n. sp. | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Polypora cestriensis* | — | — | — | — | × | — | × | — | — | — | — | × | — | × | × | × |
| *Polypora* sp. | — | — | × | — | — | × | — | — | — | — | — | — | — | — | — | — |
| *Polypora* cf. *P. spinulifera* | — | — | — | — | — | — | × | — | — | — | — | — | — | × | × | — |
| *Rhombopora* cf. *R. decipiens* | — | — | — | — | — | × | — | — | — | — | grp. | — | — | — | — | — |
| *Rhombopora persimilis* | — | — | — | — | — | — | × | — | — | — | — | — | × | — | × | — |
| *Rhombopora* sp. | — | — | — | — | × | — | × | — | — | — | — | — | — | — | — | — |
| *Rhombopora* cf. *R. tenuirama* | — | — | × | — | — | — | — | — | — | — | — | — | × | — | — | — |
| *Rhombopora wortheni* | × | × | × | — | — | — | — | — | — | — | grp.? | — | ? | — | — | — |
| *Septopora cestriensis* | — | — | — | — | — | × | × | — | — | — | — | × | × | — | × | × |
| *Septopora decipiens* var. *paradisensis* | — | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — |
| *Septopora subquadrans* | — | — | — | — | — | ? | × | — | — | — | — | × | — | × | × | × |
| *Streblotrypa nicklesi* | — | — | — | — | — | × | × | — | — | — | — | — | — | × | × | × |
| *Streblotrypa nicklesi* var. *occidentalis* | — | — | sp. | — | — | × | × | — | — | — | — | — | — | — | — | — |
| *Tabulipora paradisensis* n. sp. | — | — | — | — | — | — | × | — | — | — | — | — | — | — | — | — |
| *Tabulipora* cf. *T. rudis* | — | — | — | — | × | — | — | — | — | — | — | × | × | — | — | — |
| *Tabulipora* sp. | — | — | — | — | × | × | × | — | — | — | — | — | — | — | — | — |
| *Tabulipora tuberculata* | ? | — | — | — | × | — | — | — | × | × | × | × | — | × | × | × |
| *Thamniscus furcillatus* | — | — | — | — | — | × | × | — | — | — | — | × | × | × | × | — |
| *Ambocoelia* sp.? | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Brachythyris chesterensis* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Buxtonia arizonensis* n. sp. | — | — | — | — | ? | ? | × | — | — | — | — | — | — | — | — | — |
| *Buxtonia arkansanus* | — | — | — | × | ? | ? | ? | — | — | — | — | × | Okla. | — | — | — |
| *Camarophoria explanata* | — | — | — | — | × | × | × | — | — | — | — | — | — | — | × | × |
| *Camarotoechia mutata* | — | × | — | — | — | — | — | — | ? | × | × | × | — | — | — | — |
| *Camarotoechia purduei?* | — | — | — | × | — | — | — | — | — | — | — | — | — | × | — | — |
| *Chonetes oklahomensis* | — | — | — | × | × | × | ? | — | — | — | — | — | — | — | — | — |
| *Chonetes* sp. | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Cliothyridina sublamellosa* | — | ? | — | × | × | × | × | — | — | — | — | × | — | × | × | × |
| *Composita laevis* | — | — | — | × | × | ? | × | — | — | — | — | — | × | — | — | — |
| *Composita deltoides* n. sp. | — | — | — | × | × | — | — | — | — | — | — | — | — | — | — | — |
| *Composita* cf. *C. lewisensis* | — | × | × | — | — | — | — | — | — | — | ? | — | — | — | — | — |

THE PARADISE FAUNA AND RANGE OF SPECIES (Continued)

| | Members of Paradise Formation | | | | | | | | Warsaw | Salem | St. Louis | Ste. Genev. | Chester | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | Grp. | L. | M. | U. |
| *Composita* cf. *C. ozarkana* | — | — | — | × | × | × | × | — | — | — | — | — | — | — | — | — |
| *Composita* sp. | — | — | × | × | × | × | × | — | — | — | — | — | — | — | — | — |
| *Composita trinuclea* | — | × | — | × | × | × | ? | — | × | × | × | × | — | × | × | × |
| *Dielasma formosum?* | — | × | × | — | — | × | — | — | ? | × | × | × | — | — | — | — |
| *Dielasma illinoisensis?* | — | — | — | — | — | × | × | — | — | — | — | — | — | × | × | — |
| *Dielasma shumardanum* | — | — | — | — | × | × | × | — | — | — | — | — | — | — | × | × |
| *Dielasma* sp. | — | × | × | × | × | × | × | — | — | — | — | — | — | — | — | — |
| *Dielasmoides bisinuatus* | — | × | × | — | — | — | — | — | — | — | ? | — | — | — | — | — |
| *Echinoconchus biseriatus* | — | ? | × | — | — | — | — | — | × | × | × | — | — | — | — | — |
| *Echinoconchus rodeoensis* n. sp. | — | — | — | × | × | — | × | — | — | — | — | — | — | — | — | — |
| *Eomarginifera* aff. *E. adairensis* | — | — | — | — | — | — | × | — | — | — | — | — | — | cf. | — | — |
| *Eumetria* sp. | — | — | — | — | — | — | × | — | — | — | — | — | — | — | — | — |
| *Eumetria vera* | — | — | — | × | × | × | × | × | — | — | — | × | — | × | × | × |
| *Eumetria verneuilana* | — | — | × | × | × | × | ? | — | × | × | × | × | — | × | — | — |
| *Girtyella brevilobata* | — | ? | × | ? | ? | — | × | — | — | — | — | × | — | × | × | × |
| *Girtyella indianensis* | — | — | — | × | × | × | × | — | — | — | — | × | — | × | × | × |
| *Girtyella indianensis* var. *exporrecta* | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — | — |
| *Orthotetes kaskaskiensis* | — | — | — | ? | × | × | × | — | — | — | × | × | — | × | × | × |
| *Orthotetes* cf. *O. keokuk* | — | — | × | — | — | — | — | — | × | × | — | — | — | — | — | — |
| *Orthotetes subglobosus* var. *batesvillensis* | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — |
| *Productus elegans* | — | — | ? | × | × | × | × | — | — | — | — | × | — | × | × | × |
| *Productus elegans* var. | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Productus fasciculatus?* | — | — | — | × | × | × | ? | — | — | — | — | — | × | — | — | — |
| "*Productus*" *altonensis* | ? | — | — | — | — | — | — | — | × | × | × | — | — | — | — | — |
| "*Productus*" *inflatus* | — | — | — | — | × | — | × | — | — | — | — | — | × | × | × | — |
| "*Productus*" sp. | — | — | — | × | × | — | × | — | — | — | — | — | — | — | — | — |
| *Linoproductus ovatus* | — | × | × | × | × | × | × | × | × | × | × | × | — | × | × | × |
| *Pugnoides ottumwa?* | — | × | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Reticularia setigera* | — | — | — | — | × | × | × | — | × | × | × | × | — | × | × | × |
| *Rhipidomella burlingtonensis* | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — |
| *Rhipidomella dubia* | — | × | — | — | — | — | — | — | × | × | × | × | — | — | — | — |
| *Rhynchopora?* sp. | — | — | — | — | — | — | — | × | — | — | — | — | — | — | — | — |
| *Spirifer arizonensis* n. sp. | — | — | — | × | × | × | — | — | — | — | — | — | — | — | — | — |
| *Spirifer bifurcatus* | — | × | × | × | × | — | — | — | × | × | × | × | — | — | — | — |
| *Spirifer leidyi* | — | — | × | × | × | × | × | — | — | — | — | × | — | × | × | × |
| *Spirifer pellaensis* | — | — | × | — | — | — | — | — | — | × | × | × | — | × | × | — |
| *Spirifer pellaensis* var. *cavecreekensis* n. var. | — | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — |
| *Spirifer* sp. | — | — | — | × | × | × | — | — | — | — | — | — | — | — | — | — |
| *Spiriferina spinosa* and var. | — | — | sp. | — | — | × | × | — | — | — | — | ? | — | × | × | × |
| *Spiriferina spinosa* var. *cochisensis* n. var. | — | — | — | — | ? | — | × | — | — | — | — | — | — | — | — | — |
| *Spiriferina transversa* | — | — | — | — | × | — | × | — | — | — | — | × | — | × | × | × |
| *Deltopecten monroensis* | — | — | × | — | × | — | — | — | — | — | — | × | — | — | — | — |
| *Deltopecten* cf. *D. tahlequahensis* | — | — | — | — | × | × | — | — | — | — | — | — | — | — | — | — |
| *Deltopecten* sp. | — | — | × | — | — | — | — | × | — | — | — | — | — | — | — | — |
| *Edmondia* cf. *E. crassa* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Edmondia* cf. *E. crassa* var. *symmetrica* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Edmondia* cf. *E. fountainensis* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Edmondia genevievensis* | — | — | × | — | × | — | — | — | — | — | — | × | — | — | — | — |
| *Leda curta* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Leptodesma carboniferum?* | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Leptodesma robustum* | — | — | × | — | ? | — | — | — | — | — | — | — | — | — | — | — |
| *Modiola fountainensis* | — | — | — | — | × | — | — | — | — | — | — | × | — | — | — | — |
| *Modiola illinoiensis* | ? | × | × | — | ? | — | — | — | — | — | ? | × | — | — | — | — |

THE PARADISE FAUNA AND RANGE OF SPECIES (Continued)

| | Members of Paradise Formation | | | | | | | | Warsaw | Salem | St. Louis | Ste. Genev. | Chester | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | | Grp. | L. | M. | U. |
| *Myalina angulata* | — | — | — | — | × | — | × | — | — | — | — | — | × | — | — | — |
| *Myalina congeneris* | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Myalina monroensis* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Myalina portalensis* n. sp. | — | — | ? | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Nucula illinoiensis* | — | — | × | — | — | — | — | — | — | — | × | × | — | — | × | — |
| *Nucula* cf. *N. platynotus* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | × | — |
| *Nucula* cf. *N. randolphensis* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | × | — |
| *Paleolima* cf. *P. chesterensis* | — | — | — | — | × | — | — | — | — | — | — | — | × | — | — | — |
| *Parallelodon* cf. *P. illinoisensis* | — | — | — | — | × | — | — | — | — | — | — | — | × | — | — | — |
| *Parallelodon minima* | — | — | — | — | × | — | — | — | — | — | — | — | × | — | — | — |
| *Pterinopecten* sp. | — | — | — | × | × | — | — | — | — | — | — | — | — | — | — | — |
| *Sanguinolites* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Schizodus* cf. *S. batesvillensis* | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Schizodus* cf. *S. brannerianus* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Schizodus chesterensis* | — | — | — | — | × | — | — | — | — | — | — | — | × | — | — | — |
| *Schizodus depressus* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | × | — |
| *Streblopteria simpliciformis* | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Streblopteria simpliciformis* var. | — | — | × | — | sp. | — | — | — | — | — | — | — | — | — | — | — |
| *Sulcatipinna?* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Yoldia* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Laevidentalium* sp. | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Bellerophon sublaevis* | — | — | × | — | — | — | — | — | — | × | — | × | — | — | × | — |
| *Bucanopsis monroensis* | — | — | × | — | sp. | — | — | — | — | — | — | × | — | — | — | — |
| *Callonema?* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Euomphalus* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Euphemus* sp. | — | — | × | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Euphemus lent.formis* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Naticopsis* aff. *N. waterlooensis* | — | — | — | — | × | — | — | — | — | — | — | × | — | — | — | — |
| *Orthonychia striatulus* var. *portalensis* | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Platyceras* sp. (large) | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Straparollus similis* var. *planus* | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Straparollus* sp. | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Strophostylus splendens* | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Cycloceras randolphensis* | — | — | — | — | × | sp. | — | — | — | — | — | — | × | — | × | — |
| Nautilid | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| *Stroboceras* sp. | — | — | × | — | — | — | — | — | — | — | — | × | — | — | — | — |
| *Griffithides* sp. | × | × | × | × | × | × | × | — | — | — | — | — | — | — | — | — |
| *Paraparchites?* sp. | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — |
| Fish spines | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — |
| Shark teeth | × | × | — | — | × | × | × | — | — | — | — | — | — | — | — | — |
| Plant—undetermined | — | — | — | — | — | × | — | — | — | — | — | — | — | — | — | — |
| Plant—*Stigmaria* sp. | — | — | — | × | — | — | — | — | — | — | — | — | — | — | — | — |

Genevieve age and the Fourth represents the lower Chester. The Third member is underlain by beds of Ste. Genevieve age, and the Batesville cannot include the whole of the Ste. Genevieve because of the presence of Ste. Genevieve and so-called Chester forms in the underlying Moorefield shale. This would restrict the Batesville, then, to the upper Ste. Genevieve and the lower Chester, a conclusion tentatively reached by Girty (16, p. 25) who states:

> On the whole the evidence at hand seems to favor a correlation of the Batesville sandstone with the Cypress sandstone together with the upper part or possibly the whole of the Ste. Genevieve limestone.

*Correlation.*—The following correlations of the Paradise formation are made from the zoning of its fauna. The age of the Fayetteville and Pitkin formations is given as concluded by Snider (48, p. 39), and the subdivisions of the Brazer merely indicate the tentative conclusions reached by Girty (26) as to the general types of its faunas. The standard section of the Mississippi valley is taken from Weller (71).

*Faunal chart.*—The faunal chart lists the definitely identified forms of the Paradise formation together with their range by members. The range of specifically identified forms in the standard section of the Mississippi Valley is also given, as determined from the publications of the Geological Surveys of Iowa, Missouri, Illinois, and Kentucky. The range of tentatively identified forms in the Mississippi Valley section is given for the species s.s. In cases where the occurrence of forms in the Mississippi Valley is indicated only under a broad terminology such as "St. Louis group," the abbreviation "grp." is written under the proper heading. With few exceptions, genera are listed alphabetically under major paleontological groups. A few of the forms listed by Stoyanow (49) are not included because of lack of representation in my collections.

## PALEONTOLOGY

*Summary of fauna.*—The Paradise fauna as now known numbers 155 forms of which 83 are identified specifically, 32 tentatively assigned to species with varying certainty, and 40 referred only to genera or larger groups. Thirteen forms are described as new species or varieties.

Zoologically the fauna is distributed as follows: *Bryozoa*, 13 genera, 40 species as follows: *Trepostomata*, 2 genera, 8 species; *Cyclostomata*, 1 genus, 3 species; *Cryptostomata*, 10 genera, 29 species. *Brachiopoda*, 24 genera, 55 species as follows: *Orthacea*, 1 genus, 2 species; *Strophomenacea*, 8 genera, 17 species; *Pentameracea*, 1 genus, 1 species; *Rhynchonellacea*, 3 genera, 4 species; *Terebratulacea*, 3 genera, 8 species; *Spiriferacea*, 8 genera, 23 species. *Mollusca*, 29 genera, 50 species as follows: *Pelecypoda*, 15 genera, 33 species; *Gastropoda*, 10 genera, 13 species; *Scaphopoda*, 1 genus, 1 species; *Cephalopoda*, 3 genera, 3 species. *Echinodermata: Crinoidea*, represented by many fragmental and undetermined species. *Blastoidea*, 1 genus, several species. *Arthropoda*, 2 genera, several species. *Vertebrata*, represented by "fish spines" and shark teeth.

The flora includes at least two genera and species, a species of *Stigmaria* and the other forms as yet undetermined.

From this summary it is seen that the most abundant groups are the bryozoans, brachiopods, pelecypods, and gastropods, as far as the determined forms are concerned; there are, however, many species of crinoids among the abundant indeterminable fragments of nearly every bed of limestone in the Paradise formation.

It is believed that most of the brachiopods have been identified, but because of unfavorable preservation the pelecypods and gastropods are probably much more numerous than the faunal lists of this paper indicate. The brachiopods and mollusks must be broken from the hard limestone, resulting in damage and exfoliation. The bryozoans do not break out satisfactorily and in the desert climate the non-silicified specimens seldom weather out in well preserved condition; hence, even though the bryozoans are exceedingly abundant, the number of species identified is probably far below the actual number. Specimens of *Pentremites* thickly dot bedding planes of

hard outcropping ledges of limestone, but not being silicified they are almost never to be found in even fair condition for determination and it is impossible to break them out from the limestone.

Only species that are rather accurately identified are discussed in the following pages. Other forms are to be found on the faunal chart and among the faunal lists. The species discussed represent on the whole the more abundant and better preserved elements of the Paradise fauna. Synonomies are not complete especially as far as papers published prior to 1914 are concerned, but reference is made under each species to a paper that gives a complete synonymy. References 16, 44, 63, and 65, are of especial value.

## ANTHOZOA

A few poorly preserved corals are present in the collections, but it has not been possible to work out this group. The better specimens belong to the genera *Zaphrentis* and *Amplexus*. The *Zaphrentis* is probably *Z. spinulosum.*

## ECHINODERMATA

### BLASTOIDEA

#### Genus PENTREMITES Say

PENTREMITES sp.

The genus *Pentremites* is abundantly represented by fragmentary material and by a few badly weathered and partly exposed complete specimens. The best specimen at hand is from the main oolite and belongs to the type of *P. welleri.* Others from the Sixth and Seventh members suggest *P. spicatus* and *P. platybasis*, but it is not possible to refer them definitely. It is doubtful if determinable specimens can be obtained from the Paradise formation in the area studied.

### CRINOIDEA

Stem plates of crinoids are abundant in nearly every bed of limestone of the Paradise formation, and other separated plates are also found. *Platycrinus* is represented together with other genera, but it has not been possible to work out this group.

## BRYOZOA

### Family FISTULIPORIDAE

#### Genus ERIDOPORA Ulrich

ERIDOPORA MACROSTOMA Ulrich?

*Eridopora macrostoma* ULRICH, *1882*, Cincinnati Soc. Nat. Hist., Jour., vol. 5, no. 3, p. 137, pl. 6, figs. 2, 2*a*, Kaskaskia group.

Several poorly preserved specimens are closely related to this species. The apertures, however, are usually oval, low monticules are present, and seven cells occupy a space of 0.1 inch as compared to six in Ulrich's species.

*Horizon.*—Seventh member.

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EXPLANATION OF PLATE 80

FIGS. 1*a–c*—*Eridopora occidentalis* Hernon. n. sp. *a*, The holotype, ×3. *b*, *c*, Vertical and tangential sections of same, ×19.5. On a portion of each section, the undesirable details of calcite filling of open spaces has been removed. Seventh member, Paradise formation. (p. 673)

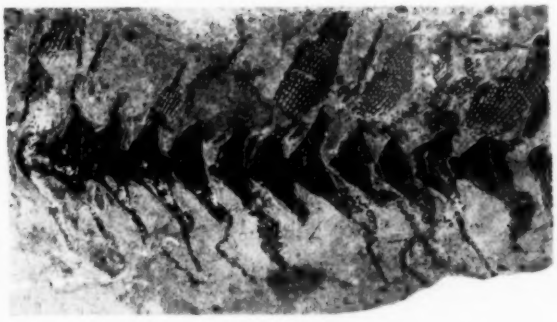
2—*Archimedes invaginatus* Ulrich. Hypotype, approximately ×1.5. Specimens of *Archimedes* usually have the fronds attached but the fronds seldom weather out well. Sixth member, Paradise formation; Stoyanow collection. (p. 675)

3—*Archimedes lativolvis* Ulrich. Hypotype, of typical preservation, ×1.5. Transverse breaks sometimes expose the attached fronds of such specimens. Seventh member, Paradise formation. (p. 675)

4*a*, *b*—*Tabulipora paradisensis* Hernon, n. sp. *a*, The holotype, ×2.25. *b*, Tangential section of same, ×19.5. The filling of the tubes is almost wholly opaque. The photograph was slightly retouched with India ink. Seventh member, Paradise formation. (p. 674)

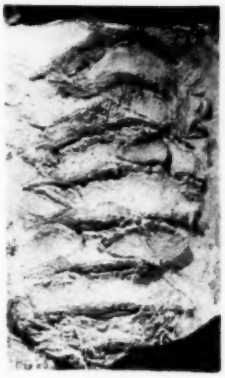
5*a*, *b*—*Phyllopora portalensis* Hernon, n. sp. *a*, The holotype, reverse side, ×1.5. *b*, Tangential section of a paratype showing parts of two fenestrules, ×19.5. The microscopic preservation is poor and the filling of open spaces is largely opaque. Section largely retouched with India ink. Fifth member, Paradise formation. (p. 676)

1a



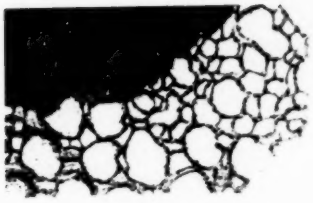
2

1b

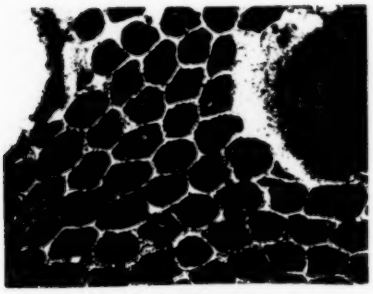


3

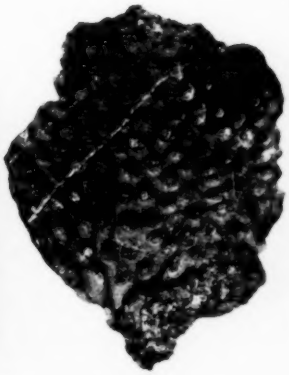
4a



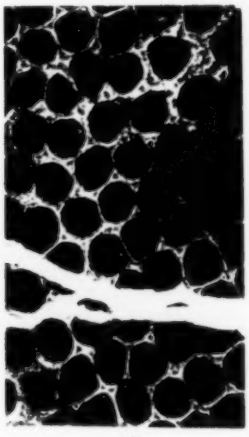
1c



5b



5a



4b

Hernon, Mississippian Bryozoa

ERIDOPORA OCCIDENTALIS Hernon, n. sp.

Plate 80, figures 1*a–c*

Zoarium incrusting, forming expansions which attain a diameter of 3 cm. and a thickness of 1 mm. or less.

Surface marked by small, long, narrow maculae which have their long axes subparallel. The maculae may be set on very low elevations and are 2½ to 3 mm. apart. Zooecial apertures average 8 to 9 in 3 mm., are separated by vesicular interspaces, and have the lunaria more prominent on one side. Near the maculae the apertures are of various sizes and the lunaria are especially prominent, forming large helmet-like hoods which cover as much as one-half of the apertures. Generally the lunaria are directed parallel to the long axes of the maculae but vary as much as 90° to the right and left.

Tangential sections show the oval-shaped apertures to be separated by one or two rows of vesicles in the intermacular regions but by from one to three series in the maculae themselves. Vertical sections show the tubes to be quite oblique at first but nearly direct in the mature region. There are no diaphragms as far as known. The number of rows of vesicles seen in vertical sections is an apparent number varying with the relation of the section to the zooecial interspaces.

*Remarks.*—This species resembles *E. punctifera* Ulrich but has only one to two rows of vesicular tissue as compared to two to three, has 7 apertures in 0.1 inch as compared to 8, and has the maculae more closely spaced. From *E. macrostoma* Ulrich it differs in its smaller cells, 7 in 0.1 inch as compared to 6, its oval apertures, and the prominent lunaria.

*Horizon.*—Seventh member.

## Family BATOSTOMELLIDAE

### Genus BATOSTOMELLA Ulrich

BATOSTOMELLA ARMATA Girty

Plate 81, figure 6

*Batostomella? armata* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 192, Fayetteville shale.

Excellent specimens are referred to this species. The Arizona specimens attain a slightly larger size and so far as known have the thickened walls fused in the mature region and never moniliform. In their measurements and other features they conform very closely to Girty's description. In spite of the fact that Girty's types were not figured, the writer believes that the Paradise form is identical with his. A single specimen associated with normal ones differs in having no diaphragms, a narrow cortical region, and more regularly arranged apertures.

*Horizon.*—From the Chester portion of the Paradise formation, exact horizon unknown.

BATOSTOMELLA SPINULOSA Ulrich

*Batostomella spinulosa* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 434, pl. 75, figs. 1–1*e*, Chester group.

Represented by abundant but mostly poorly preserved specimens.

*Horizon.*—Sixth and Seventh members.

### Genus TABULIPORA Young

TABULIPORA cf. T. RUDIS (Ulrich)

*Stenopora rudis* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 444, pl. 72, figs. 8–8*b*, Chester group.

Abundant specimens of a "*Stenopora*" are found at the top of the main oolite. Ordinarily they break from the limestone as inner molds of the hollow branching colonies showing the strong transverse and weak longitudinal ridges and furrows of the epitheca. The branches bifurcate at intervals of from 1.5 to 4 cm., the best specimen available being 6 cm. long, although incomplete. The diameter of the inner molds varies from 2.5 to 9 mm., the latter thickness at bifurcations. Thin sections are very like those of *T. rudis* except that the acanthopores are somewhat more numerous. The poor preservation of the surface prevents certain reference of the form.

*Horizon.*—Fifth member.

TABULIPORA PARADISENSIS Hernon, n. sp.
Plate 80, figures 4*a*, *b*

Zoarium a laminar expansion attaining a diameter of 4 cm., with a thin epitheca which has been seen only in thin section. As far as known the zoaria consist of single layers from 1 to 2 mm. thick.

Zooecial tubes prostrate at first but abruptly curving to the surface. Walls thin, flexuous, and irregularly moniliform. Diaphragms about 3 to 6 in number in each tube, from one-half to their diameter apart, and centrally perforated. Acanthopores irregular in distribution, occupying the angles between zooecia or slightly encroaching on the cavity. In certain areas the acanthopores are present on all the angles but in others they seem to be missing.

Externally the surface is obscurely spinulose in certain areas and is marked by small sharply elevated monticules averaging slightly less than 3 mm. apart and made up of cells of about normal size with several large mesopores(?) in the central area. Between the monticules the polygonal cells are in places arranged in intersecting series with about nine to eleven, usually ten, apertures in 3 mm. Mesopores rare in the spaces between monticules.

*Remarks.*—This species differs from all others in its sharply elevated, closely spaced monticules. It agrees rather closely with *T. tuberculata* in its general features. *T. montifera* Ulrich has prominent monticules, but these are larger and less closely spaced, and moreover its apertures average somewhat larger.

*Horizon.*—Seventh member.

TABULIPORA TUBERCULATA (Prout)

*Flustra tuberculata* PROUT, *1859*, St. Louis Acad. Sci., Trans., vol. 1, p. 447, pl. 17, figs. 3–3*f*, Second *Archimedes* limestone.
*Stenopora tuberculata* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 441, fig. 17, Chester group.—CONDRA, *1903*, Nebraska Geol. Survey, vol. 2, pt. 1, p. 42, pl. 4, fig. 6, Warsaw, St. Louis, and Chester groups, Coal Measures.—MATHER, *1915*, Sci. Lab. Denison Univ., Bull. 18, p. 111, pl. 4, figs. 3–5, Morrow group.

This well known species is abundant in the Paradise formation. The specimens are typical in every way, with the possible exception of one which seems to be part of a large hollow branch. Some parts of tangential sections have the interspaces between zooecia marked by from one to three rows of very small dots, a feature not shown by Ulrich's figures.

*Horizon.*—First(?) and Fifth members.

## Family FENESTELLIDAE

### Genus FENESTELLA Lonsdale

FENESTELLA CESTRIENSIS Ulrich

*Fenestella cestriensis* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 547, pl. 51, figs. 5–5*b*, Chester group.

The specimens are entirely typical of the Mississippi Valley species.

*Horizon.*—Second(?), Third and Seventh members.

FENESTELLA MULTISPINOSA Ulrich

*Fenestella multispinosa* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 540, pl. 50, figs. 3–3*c*, Keokuk group.

The specimens so identified conform closely to Ulrich's species. The reverse sides of the specimens show great numbers of small pits arranged in longitudinal rows; these are interpreted as remnants of the granular structure characteristic of the species.

*Horizon.*—Fifth member.

FENESTELLA TENAX Ulrich

*Fenestella tenax* ULRICH, *1888*, Sci. Lab. Denison Univ., Bull., vol. 4, p. 71, Waverly group; *1890*, Illinois Geol. Survey, vol. 8, p. 546, pl. 51, figs. 2–2*c*, Warsaw and Chester.

All specimens of this abundant species are of Chester type.

*Horizon.*—Second(?) to Seventh members.

### Genus ARCHIMEDES Leseur

The species of *Archimedes* found in the Paradise formation vary considerably in certain characters. The number of fenes-

trules in a certain distance varies greatly not only among individuals of the same species but also among the fronds and different parts of a single frond of one individual. The number of branches in any given distance varies in the same way. The best characters for determination of species among the Paradise representatives are as follows: the number of volutions in a given distance, the relative diameter of the shaft as compared to that of the flange, the relative slopes from the periphery of the flange above and below, and the number of apertures in a given distance.

ARCHIMEDES CONFERTUS Ulrich

*Archimedes, confertus* ULRICH, *1905*, U. S. Geol. Survey, Prof. Paper 36, p. 34, pl. 4, figs. 6–8, Birdsville formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 284, pl. 41, figs. 1*a*, *b*, Paint Creek and Golconda.

*Archimedes*, n. sp. STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 318, Paradise formation.

A large number of specimens are assigned to this species, although it has not been adequately described as far as limits of variation are concerned. The Paradise form has the following characters: diameter of shaft, 2 to 3.5 mm.; number of volutions in 2 cm., 10 to 13, usually about 11.5; angle of divergence of fronds, 60° to 70°. A fair specimen with exposed fronds has the following measurements: number of zooecia in 2.5 mm., 13 to 14; number of branches in 5 mm., about 12; and number of fenestrules in 5 mm., 10. The flange is wide compared to the shaft itself. It is possible that the Paradise form represents a new species or variety, but specimens can be chosen which conform closely to Ulrich's types. A number of very slender forms having 13 to 16 volutions in 2 cm. differ from *A. perminimus* Ulrich in the greater diameter of the shaft. The angle of divergence of the fronds is about the same as that of *A. confertus*, and it is believed that they represent terminal parts of specimens of that species.

*Horizon.*—Fifth to Seventh members.

ARCHIMEDES INVAGINATUS Ulrich
Plate 80, figure 2

*Archimedes invaginatus* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 575, pl. 63, figs. 11*a–c*, Chester group.

*Archimedes* cf. *A. invaginatus* STOYANOW, 1926, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

This species is abundant in several horizons. Many specimens have somewhat smaller fenestrules than Ulrich's types, and possibly these more finely fenestrated forms should be separated as a variety, though there are all gradations between them and typical fronds.

*Horizon.*—Fifth to Seventh members.

ARCHIMEDES LATIVOLVIS Ulrich
Plate 80, figure 3

*Archimedes lativolvis* ULRICH, *1905*, U. S. Geol. Survey, Prof. Paper 36, p. 34, pl. 4, fig. 4, Birdsville formation.

This easily recognized form is found abundantly and is restricted to the upper horizons of the Paradise formation. The specimens have the following characters: diameter of shaft, 2 to 4 mm.; number of volutions in 2 cm., 5 to 6; angle of divergence of fronds, 70° to 85°; zooecia in 5 mm., 21 to 23; branches in 1 cm., 20 to 24; fenestrules in 1 cm., 17 to 24. The flange is proportionately very wide.

*Horizon.*—Sixth(?) and Seventh members.

ARCHIMEDES PROUTANUS Ulrich

*Archimedes proutanus* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 576, pl. 63, figs. 3–3*d*, 11–11*b*, Chester group.—WELLER, *1920*, Illinois Geol. Survey, Bull. 41, p. 346, pl. 7, fig. 28, Paint Creek formation; *1931*, Kentucky Geol. Survey, Symposium, p. 284, pl. 41, fig. 3, Paint Creek to Glen Dean.

This species is abundant, though well preserved specimens are difficult to obtain from the hard *Archimedes* limestone. The form is entirely typical except that rare individuals have 8.5 volutions in 2 cm., a little above Ulrich's limits.

*Horizon.*—Fifth, Sixth(?) and Seventh (?) members.

### Genus POLYPORA McCoy

#### POLYPORA CESTRIENSIS Ulrich

*Polypora cestriensis* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 594, pl. 55, figs. 4–4*b*; pl. 60, figs. 7–7*c*, Chester group.

This species and a variety are very abundant as molds. They conform closely to Ulrich's types except for the variant mentioned, which is typical save for its branches and fenestrules, 9 branches and 8 fenestrules in 1 cm.

*Horizon.*—Fifth and Seventh members.

### Genus PHYLLOPORA King

#### PHYLLOPORA PORTALENSIS Hernon, n. sp.

Plate 80, figures 5*a*, *b*

Zoarium a flabellate expansion, poriferous on the inner(?) side, and composed of anastomosing branches whose width on the reverse varies from 0.5 to 1 mm. and from 1 to 1.4 mm. on the obverse, and which increase in number by an occasional bifurcation.

The reverse is a rounded-mesh network with fenestrules rather irregularly arranged in longitudinal rows and curved irregular transverse rows. Fenestrules oval or circular, about 1.2 to 1.4 mm. in diameter on the reverse and decreasing gradually to a diameter of 0.6 to 0.9 mm. on the obverse side. Longitudinally the regular rows have about 4 fenestrules in 1 cm., and the more regular of the transverse rows show from 5 to 6 in the same distance. Branches anastomose as viewed from the reverse, their continuity being determined by the fine longitudinal striations that mark them.

Obverse side flattened with the fenestrules more oval than on the reverse and the apertures small. When regularly arranged there are about 9 zooecia in 2.5 mm., and 6 to 7 usually alternating rows on each branch.

*Remarks.*—Occasionally the anastomosing branches do not quite join and in such cases are connected by a very wide but very short non-poriferous dissepiment. This feature suggests a close relation to *Polypora*, though the anastomosing character is much stronger than in typical species of that genus. A single associated specimen differs in having a larger network and may represent a variety.

*Horizon.*—Fifth member.

### Genus THAMNISCUS King

#### THAMNISCUS FURCILLATUS Ulrich

*Thamniscus furcillatus* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 609, pl. 62, figs. 9–9*b*, Chester group.

This species is common, but well preserved specimens are rather rare.

*Horizon.*—Sixth and Seventh members.

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EXPLANATION OF PLATE 81

FIGS. 1*a–c*—*Buxtonia arizonensis* Hernon, n. sp. Pedicle, lateral, and posterior views of the holotype, ×1.5. Seventh member, Paradise formation. (p. 681)

2*a*, *b*—*Productus elegans* Norwood and Pratten. *a*, Hypotype, fractured along the diaphragm, ×1.5. *b*, Same, showing the diaphragm, ×1.5. Fifth member, Paradise formation; Stoyanow collection. (p. 680)

3—*Echinoconchus rodeoensis* Hernon, n. sp. Pedicle view of the holotype, ×1.5. Fifth member, Paradise formation. (p. 679)

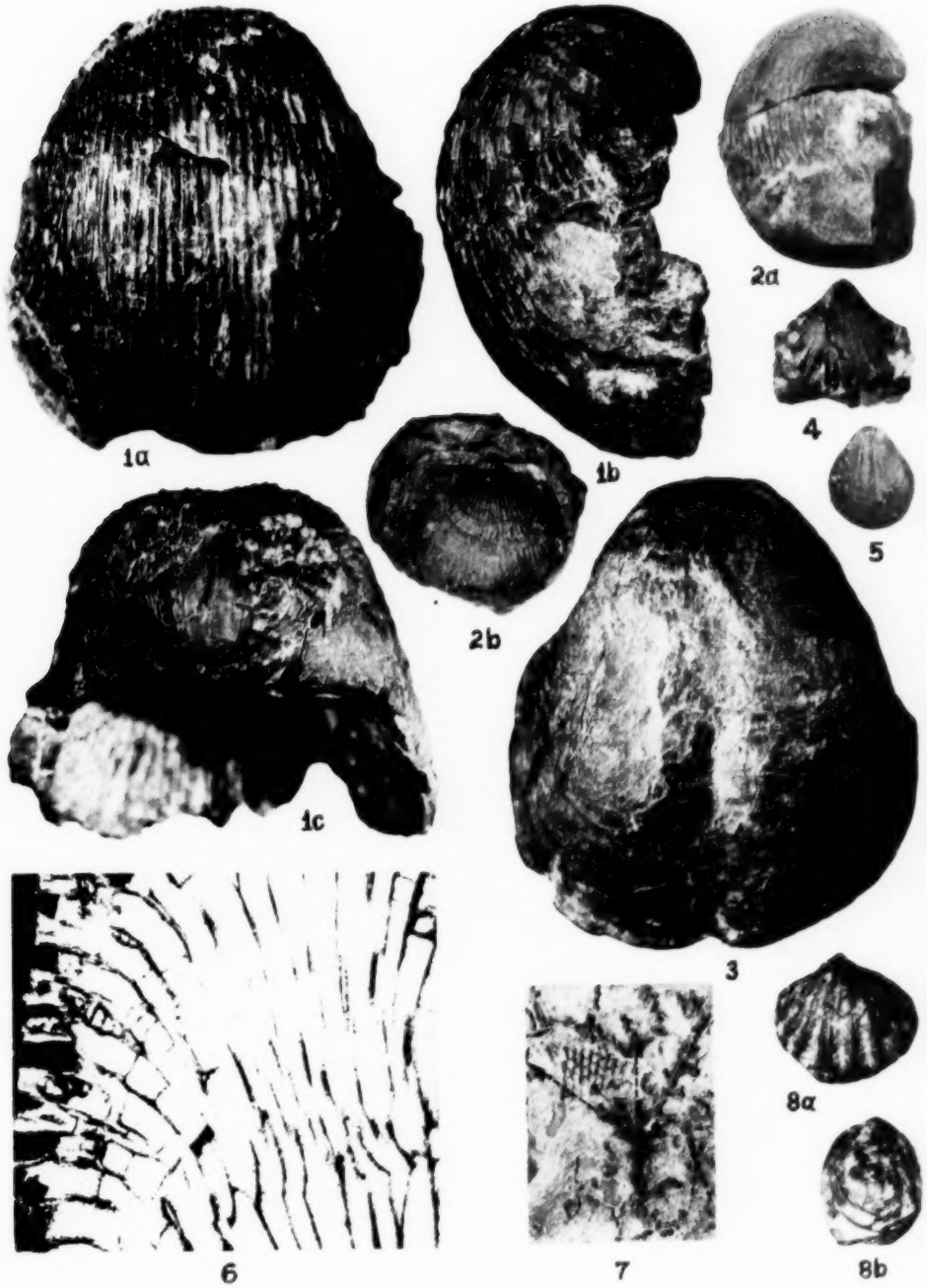
4—*Pugnoides ottumwa* (White)(?). A nearly complete pedicle valve, ×1.5. Second member, Paradise formation. (p. 684)

5—*Girtyella indianensis* (Girty). Hypotype. Pedicle view of a complete but exfoliated specimen, ×1.5. Fifth member, Paradise formation. (p. 685)

6—*Batostomella armata* Girty. Hypotype. Longitudinal section showing somewhat more than half of the specimen, ×19.5. Slightly retouched. Upper Paradise formation. (p. 673)

7—*Septopora decipiens* var. *paradisensis* Hernon, n. var. The holotype, ×2.25. Seventh member, Paradise formation. (p. 677)

8*a*, *b*—*Camarotoechia purduei* Girty(?). Brachial and lateral views of a common type of specimen having three plications on the fold, ×1.5. Fourth member, Paradise formation. (p. 683)




Hernon, Mississippian Brachiopoda and Bryozoa

## Family ACANTHOCLADIIDAE

### Genus SEPTOPORA Prout

#### SEPTOPORA CESTRIENSIS Prout

*Septopora cestriensis* PROUT, *1859*, St. Louis Acad. Sci., Trans., vol. 1, p. 448, pl. 18, figs. 2–2*c* (part), upper *Archimedes* limestone (not Meek and Worthen, 1870).—ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 628, pl. 64, figs. 1–1*b*, Chester group.

This species is common but like many of the Paradise Bryozoa is represented by few good specimens.

*Horizon.*—Sixth and Seventh members.

#### SEPTOPORA DECIPIENS var. PARADISENSIS Hernon, n. var.

Plate 81, figure 7

A large number of specimens are thus identified. Most individuals are incomplete, in fact are easily mistaken for *Pinnatopora* if the poriferous dissepiments are not seen. The best specimen available is an incomplete pinnate expansion about 1 cm. long with incomplete branches up to 5 mm. long. The measurements of a large number of specimens are as follows: width of midrib, 0.5 to 0.9 mm.; width of branches, 0.3 to 0.5 mm.; angle of branches, 55° to 66°; pinnae on midrib, about 10 to 12 in 1 cm.; pinnae or poriferous dissepiments on branches, about 10 to 11 in 1 cm.; zooecia on midrib, 18 to 20 in 5 mm., on branches 18 to 19; zooecia in two alternating rows except at bifurcations where there are three; rows separated by a median ridge.

Reverse smooth to finely striated as preserved and bearing a pore at the upper or acute angle of the junction between a branch or pinna and its midrib.

The form is distinguished from *S. decipiens* by the closer spacing of the zooecial apertures and by the greater development of the branches. If Ulrich's type is complete the Paradise specimens probably represent a new species. *S. pinnata* Ulrich differs in being much more irregular in its branching and has the pinnae less closely spaced.

*Horizon.*—Sixth and Seventh members.

#### SEPTOPORA SUBQUADRANS Ulrich

*Septopora subquadrans* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 629, pl. 56, figs. 7, 8; pl. 64, figs. 2–2*b*, upper Chester group.

The specimens so identified are identical with Ulrich's types in all important features but have slightly larger fenestrules, a feature not considered to be of varietal value.

*Horizon.*—Sixth(?) and Seventh members.

## Family RHABDOMESONTIDAE

### Genus RHOMBOPORA Meek

#### RHOMBOPORA PERSIMILIS Ulrich

*Rhombopora persimilis* ULRICH, *1884*, Cincinnati Soc. Nat. Hist., Jour., vol. 7, no. 1, p. 30, pl. 1, figs. 7–7*d*, Kaskaskia group; *1890*, Illinois Geol. Survey, vol. 8, p. 659, pl. 70, fig. 3, Chester group.

Abundant poorly preserved specimens are referred to this species. They agree very well with the types except that they attain a larger size. Ulrich (1890) figures an individual of the size commonly found in the Paradise formation.

*Horizon.*—Seventh member.

#### RHOMBOPORA WORTHENI Ulrich

*Rhombopora wortheni* ULRICH, *1884*, Cincinnati Soc. Nat. Hist., Jour., vol. 7, no. 1, p. 32, pl. 1, figs. 4–4*b*, Lower Carboniferous sandy shale—either St. Louis group or lower Kaskaskia. On page 655 of vol. 8, Illinois Geol. Survey, Ulrich states: from the Lower Carboniferous (Keokuk?) deposits of Kentucky.

Excellent specimens of this species are typical in every way.

*Horizon.*—First to Third members.

### Genus STREBLOTRYPA Ulrich

#### STREBLOTRYPA NICKLESI Ulrich

*Streblotrypa nicklesi* ULRICH, *1890*, Illinois Geol. Survey, vol. 8, p. 667, pl. 71, figs. 9–9*c*, Chester group.

Well preserved specimens of this abundant species are not common.

*Horizon.*—Sixth and Seventh members.

STREBLOTRYPA NICKLESI var. OCCIDENTALIS Hernon, n. var.

The branches vary from 1.1 to 1.5 mm. in diameter; the branch interval at least 2 cm. or more; the zooecial apertures are oval, 4.5 to 5 in 2 mm. longitudinally, and 7 in 2 mm. diagonally, and there are about 20 regular rows around the branch; the interspaces between the apertures are occupied by from 6 to 14 small pores usually arranged in 2 or 3 rows. This variety is readily recognized by its large size.

*Horizon.*—Sixth and Seventh members.

## BRACHIOPODA

### Family STROPHOMENIDAE

### Genus ORTHOTETES Fischer

ORTHOTETES KASKASKIENSIS (McChesney)

*Orthis kaskaskiensis* McCHESNEY, *1860*, Description New Paleozoic Fossils, p. 31.
*Derbya kaskaskiensis* HALL and CLARKE, Paleontology of New York, vol. 8, pt. 1, pl. 11–B, fig. 6, Chester limestone.
*Orthotetes kaskaskiensis* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 77, pl. 6, figs. 1–14, Ste. Genevieve and Chester.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 61, figs. 1–3, Gasper formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 286, pl. 42, figs. 10*a*, *b*, Ste. Genevieve and Chester.

An *Orthotetes* is well represented in the higher beds of the Paradise formation. Usually the material is fragmentary but a few good specimens were obtained which had partly weathered from the matrix. While there is some variation in size, all the specimens conform very closely to the species as interpreted by Weller (1914). It is of interest that some specimens approach the genus *Derbya* in the relation of the dental plates to the median septum. It is probable that the form is represented in the collection assigned to *O. subglobosus* var. *batesvillensis*.

*Horizon.*—Fourth(?) to Seventh members.

ORTHOTETES SUBGLOBOSUS var. BATESVILLENSIS Girty

*Orthotetes subglobosus* var. *batesvillensis* GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 42, pl. 1, figs. 1–5, Batesville sandstone.

A single collection includes rather fragmentary specimens of an *Orthotetes* which differs from *O. kaskaskiensis* in its larger size and the inflated umbo of the brachial valve. The ornamentation varies considerably but falls within the limits of *O. subglobosus* itself together with the varieties *batesvillensis* and *protensus*. The specimens are close to the variety *batesvillensis* in shape and convexity and hence the whole group is referred to that form.

*Horizon.*—Fourth member.

### Family PRODUCTIDAE

### Genus CHONETES Fischer

CHONETES OKLAHOMENSIS Snider

*Chonetes oklahomensis* SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 76, pl. 3, figs. 12–15, Mayes, Fayetteville, and Pitkin.
*Chonetes sericeus* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

The size of the specimens so identified varies considerably, the length ranging from 7 to 10 mm. and the width from 10 to 16 mm., with rare larger individuals. The average dimensions are length 8 mm. and width 14 mm. There are 8 to 10 spines on each side of the beak along the cardinal margin. They are erect and closely spaced near the beak but are progressively farther apart and directed more obliquely toward the cardinal extremities. The regular radiating costae increase by intercalation and bifurcation and 5 to 6 occupy a space of 1 mm. near the anterior border. The Paradise form agrees closely with Snider's species in all details other than size and that difference is not thought to be of specific importance.

*C. loganensis* Hall and Whitfield is a similar form but has only three or four spines on either side of the beak and

averages somewhat higher than *C. oklahomensis*.

*Horizon.*—Fourth to Sixth, and Seventh(?) members.

### Subfamily PRODUCTINAE

The Productinae are represented by a number of genera and species in the Paradise formation. The writer has had much difficulty in assigning several species to the recently devised "genera." Now that the genus *Productus* is restricted to the productids possessing an internal diaphragm, there is, unfortunately, no general generic term to include some of the groups which are of subgeneric value. In this paper, species which cannot be assigned clearly to any of the generic groups are identified as "*Productus*" with a discussion.

### Genus ECHINOCONCHUS Weller

#### ECHINOCONCHUS BISERIATUS (Hall)

*Productus biseriatus* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 12, St. Louis limestone; *1883*, Indiana Geol. Survey, 12th Rep., p. 325, pl. 29, figs. 8–12, St. Louis group.—GIRTY, U. S. Geol. Survey, Bull. 439, p. 46, pl. 3, figs. 10–11, Moorefield shale.

*Echinoconchus biseriatus* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 141, pl. 17, figs. 10–15, Salem limestone.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

*Pustula biseriata* BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 57, fig. 14, low in the Warsaw.

No well preserved pedicle valves of this species are at hand but a number of excellent external molds of brachial valves show evidence of the two sets of spines, on each concentric band, characteristic of the species. The size and outline of the external molds is very like that of the types.

*Horizon.*—Second(?) and Third members.

#### ECHINOCONCHUS RODEOENSIS Hernon, n. sp.

Plate 81, figure 3

*Echinoconchus punctatus* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

This form is quite distinct from all described Mississippian and Pennsylvanian species of this genus, but conforms rather closely to the Permian Phosphoria species *E. nevadensis* (Meek) (U. S. Geol. Survey 40th Par., vol. 4, p. 64, pl. 8, figs. 2–2*e*, 1877).

The Paradise form is marked by spines, those on and near the auriculations being large and erect and arranged in intersecting rows, the more prominent of which extend obliquely toward the umbonal region. The umbo is marked by one size of spines, but the rest of the shell is concentrically banded, each band bearing two or three rows of oblique spines. The arrangement consists of a row of medium to large spines on the posterior portion of each band, in some places followed by a second row of staggered large spines; in addition, there is always a row of fine closely set spines.

The high narrow outline and the narrow well-defined sinus characterize the species.

### Genus EOMARGINIFERA Muir-Wood

#### EOMARGINIFERA aff. E. ADAIRENSIS (Drake)

*Productus* (*Marginifera*) *adairensis* DRAKE, *1898*, Am. Phil. Soc., Proc., vol. 36, p. 402, pl. 9, figs. 1–3. Reprint in Leland Stanford Junior Univ. Pub., Contr. Biol. Hopkins Seaside Lab. No. 14, same date, page, etc., Boone limestone and Boston group.

*Productus adairensis* GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 50, pl. 3, fig. 6, Batesville sandstone.

*Marginifera adairensis* SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 84, pl. 4, figs. 12–14, Mayes and Fayetteville.

A few brachial valves obtained near the top of the Paradise formation are believed to represent this species. The form is identical with Girty's specimen (1915) from the Batesville sandstone. The specimens are preserved partly as interiors of brachial valves but are exfoliated in the region of the internal ridge. *Producti* of this type have been given the generic name *Eomarginifera* by Muir-Wood (34, p. 103).

*Horizon.*—Seventh member.

### Genus PRODUCTUS Sowerby (emend. Muir-Wood)

#### PRODUCTUS ELEGANS Norwood and Pratten

Plate 81, figures 2*a*, *b*

*Productus elegans* NORWOOD and PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 3, pl. 1, figs. 7*a–c*, Mountain limestone of Illinois.

*Diaphragmus elegans* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, p. 217, Fayetteville shale.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 136, pl. 12, figs. 8–17, Chester group.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 59, pl. 3, figs. 5, 5*a*, Batesville sandstone.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 65, figs. 6–9, Golconda limestone.—GIRTY, *1927*, U. S. Geol. Survey, Prof. Paper 152, pl. 23, figs. 20–27, Brazer limestone.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. 9*a*, *b*, Ste. Genevieve and Chester.

Specimens of this species from the upper beds of the Paradise formation are usually badly crushed and dwarfed, but well preserved specimens of normal size are common in lower horizons.

The specimens are very close to those from the Mississippi Valley, but two varieties are found, one of which is separated with some doubt as *P. fasciculatus* and the other is discussed here. The typical specimens differ somewhat in size, width, flattening of the central portion of the pedicle valve, and in the presence or absence of fasciculation toward the anterior margin.

A variety differs from the typical form in being a broader shell with finer, more depressed, flexuous costae. Girty (1927, figs. 24–27) figures this type from the Brazer limestone. It is rare in the Paradise formation.

Since Muir-Wood (33) has established the presence of the internal diaphragm in *Anomites productus* Sowerby, the type of the genus, the species under discussion belongs to *Productus* s.s., of which *Diaphragmus* is a synonym.

*Horizon.*—Third (?) to Seventh members. The variety occurs in the Fifth member.

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EXPLANATION OF PLATE 82

FIGS. 1—*Spiriferina spinosa* var. *cochisensis* Hernon n. var. Pedicle view of the holotype, a crushed specimen retaining both valves, and with perfectly preserved surface, ×2.25. Seventh member, Paradise formation; Stoyanow collection. (p. 685)

2*a–c*—*Spirifer arizonensis* Hernon, n. sp. *a*, *b*, Pedicle and posterior views of two pedicle valves, syntypes, ×1.5. The lateral slopes of many specimens are much more concave than those of *b*. Fourth member, Paradise formation. *c*, An immature specimen, paratype, ×1.5. Sixth member, Paradise formation. (p. 686)

3*a*, *b*—*Spirifer pellaensis* var. *cavecreekensis* Hernon, n. var. *a*, An exfoliated pedicle valve, syntype, ×1.5. Better preserved specimens with less complete outlines are identical with the specimen figured by Girty (1927). *b*, The best brachial valve found, syntype, ×1.5. Seventh member, Paradise formation. (p. 687)

4*a*, *b*—*Dielasmoides bisinuatus* Weller. Hypotype. Pedicle and anterior views of a perfect specimen, ×1.5. Second member, Paradise formation. (p. 684)

5*a*, *b*—*Camarophoria explanata* (McChesney). Hypotype. Anterior and pedicle views of a large specimen, ×1.5. Sixth member, Paradise formation. (p. 683)

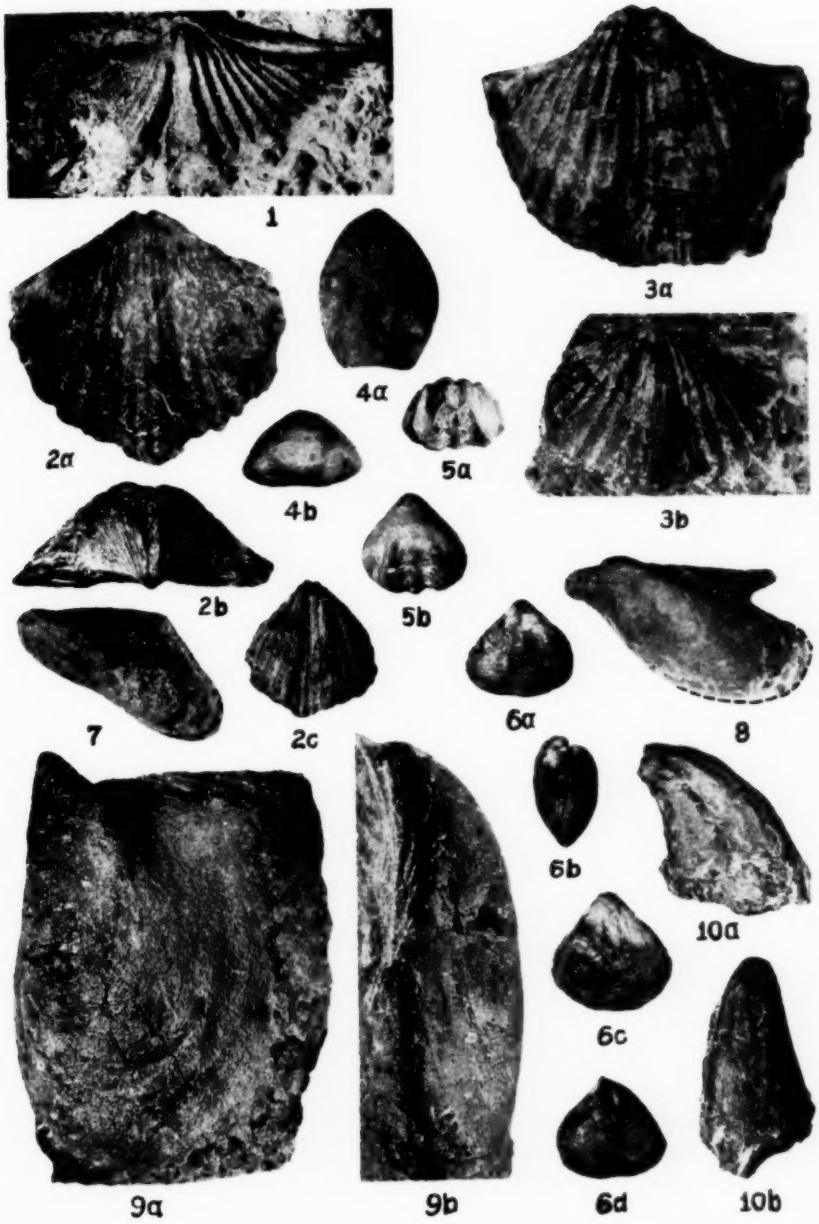
6*a–d*—*Composita deltoides* Hernon, n. sp. Pedicle, lateral, pedicle, and brachial views of four specimens, syntypes, ×1.5. Fifth member, Paradise formation. (p. 689)

7—*Modiola illinoiensis* Worthen. Hypotype. A specimen of the Batesville type, ×1.5. The Illinois type of this species is likewise common but occurs alone. Third member, Paradise formation. (p. 692)

8—*Leptodesma robustum* Girty. Hypotype. A left valve, restored posteriorly, ×1.5. Third (?) member, Paradise formation; Stoyanow collection. (p. 690)

9*a*, *b*—*Myalina portalensis* Hernon, n. sp. Lateral and anterior views of the holotype, a left valve, ×1.5. Third (?) member, Paradise formation; Stoyanow collection. (p. 691)

10*a*, *b*—*Orthonychia striatulus* var. *portalensis* Hernon, n. var. Two views of the holotype, ×1.5. Fifth member, Paradise formation. (p. 693)




Hernon, Mississippian Brachiopoda and Mollusca

PRODUCTUS FASCICULATUS McChesney?

*Productus fasciculatus* McCHESNEY, *1860*, Description New Paleozoic Fossils, p. 38, Kaskaskia limestone.
*Diaphragmus elegans* GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 51, pl. 4, figs. 4, 5, Moorefield shale.
*Diaphragmus fasciculatus* GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 56, pl. 3, figs. 1–4, Batesville sandstone.

The specimens thus identified are similar to *P. elegans* except for the flattening of the umbonal region, the presence of a distinct mesial sinus in the pedicle valve, the shorter and less incurved ventral beak, and the wider more spreading shape. Fasciculation of the costae toward the anterior border is not a basis of separation from *P. elegans*, as both forms show this feature.

The identification is queried because the form grades into *P. elegans*. It seems to be merely a variety of that species that is not always easily separated.

*Horizon.*—Fourth to Sixth, and Seventh(?) members.

"PRODUCTUS" ALTONENSIS Norwood and Pratten

*Productus altonensis* NORWOOD and PRATTEN, *1855*, Philadelphia Acad. Sci., Jour., (2), vol. 3, p. 7, pl. 1, figs. 1*a–c*, Mountain limestone of Illinois.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 124, pl. 10, figs. 14–24, Salem limestone.

*Productus altonensis* is represented by two specimens from the Stoyanow collections, probably obtained from the lower part of the formation, judging from the nature of the matrix. The form is entirely typical of the eastern species. Oval markings, apparently punctations, occur abundantly. They are arranged in radial lines, about three or four of which occur on each costa. The pits are large and almost coalesce with the result that the radial lines appear to be fine striae. The generic reference of this species is not clear. It may belong to *Dictyoclostus* but the semireticulation is less strongly developed and a few spines are present on the brachial valve.

"PRODUCTUS" INFLATUS McChesney

*Productus inflatus* McCHESNEY, *1860*, Description New Paleozoic Fossils, p. 40, Carboniferous limestone, Leavenworth, Ind.; Illustr. New Spec. Fossils, pl. 6, figs. 1*a–c*.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 111, pl. 10, figs. 1–6, Okaw formation.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 61, fig. 13 (Gasper formation), and figs. 14–17, Ste. Genevieve.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 6*a*, *b*, Chester.

This species is not abundant except in a single horizon near the top of the Paradise formation. Specimens from a lower horizon are smaller, narrower, and have a more prominent sinus than those from the higher bed. Both types, however, have inflated auriculations, and spine bases along the cardinal margin.

The generic reference of this species is not clear. The shell is moderately semireticulated and apparently lacks the diaphragm. It may be referable to the genus *Dictyoclostus*.

*Horizon.*—Fifth and Seventh members.

Genus BUXTONIA Thomas

BUXTONIA ARKANSANA (Girty)

*Productus arkansanus* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 216, Fayetteville shale; *1915*, U. S. Geol. Survey, Bull. 593, p. 46, pl. 2, figs. 5–7, Batesville sandstone.

Well preserved specimens of this species are rare in the Paradise formation. Girty's types were not figured, hence the writer is relying on the original description and taking the figured Batesville form (Girty, 1915) as the type. The Paradise form has erect spines on the auriculations, a feature not mentioned by Girty. *B. arizonensis*, n. sp. is a closely related species.

*Horizon.*—Fourth, Fifth(?), Sixth(?), Seventh(?) members.

BUXTONIA ARIZONENSIS Hernon, n. sp.
Plate 81, figures 1*a–c*

Shell large, length and width about equal, hinge-line a little less than the greatest width. Dimensions of the type

are: length 40 mm., width about 42 mm., convexity of pedicle valve about 20 mm.

Pedicle valve gibbous, the radius of curvature becoming gradually less from the anterior margin to the beak; umbonal region obtusely pointed to the beak, which is slightly protuberant beyond the hinge-line; median portion of the valve flattened in the umbonal region, the flattening becoming a shallow but well marked sinus anteriorly. Surface abruptly curved from the median portion into the lateral slopes, which flare moderately. Surface marked by strong rounded radiating costae, which increase in number by bifurcation and intercalation, with a few ribs dying out anteriorly; four or five costae occupy a space of 5 mm. At intervals of about 10 mm. on the median slopes each costa gives off a strong oblique spine marked by a prominent node. Toward the auriculations the spines are smaller and more numerous and on the ears are closely spaced and nearly erect. Faint concentric wrinkles are present posteriorly, being strongest on the auriculations and nearly obsolete on the median portion. Lines of growth poorly expressed.

Brachial valve nearly flat in the visceral area, with a small median concavity at the hinge-line which passes into a broad low anteriorly-widening fold. On either side of the fold is a slight radial sinuosity. The margin of the visceral area is marked by an abrupt geniculation of the valve. Surface of valve marked by costae similar to those of the opposite valve except that the spines are smaller, more numerous, and more erect. The concentric wrinkles are almost obsolete as are the lines of growth. The internal diaphragm is not developed.

*Remarks.*—*B. arkansana* is a smaller less inflated shell with a narrow and much less prominent umbo and somewhat discontinuous costae. The two species are closely related, however. *P. inflatus* var. *coloradoensis*, figured by Girty (16) from the Batesville, and his (26) *P.* aff. *P. keokuk* from the Brazer are closely related to each other; both resemble *B. arizonensis* but can be readily distinguished by their broader shape and different ornamentation.

*Horizon.*—Fifth (?), Sixth (?) and Seventh members.

### Genus LINOPRODUCTUS Chao

#### LINOPRODUCTUS OVATUS (Hall)

*Productus ovatus* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1, St. Louis limestone.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 132, pl. 16, figs. 1–15, Kinderhook to Chester; *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 8*a*, *b*, Kinderhook to Chester; also note *P. ovatus* var. *minor* SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 79, pl. 3, figs. 19–21, Fayetteville formation.

*Productus laevicosta* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

This common Mississippian species is represented abundantly throughout the upper half of the Paradise formation. Much variation in size occurs, but the general characters are constant. Separation of the small specimens as *L. ovatus* var. *minor* Snider could be made, but the wholesale dwarfing of many species at several horizons in the Paradise formation makes this undesirable.

The genus *Linoproductus* commonly has a geniculate brachial valve. Figured brachial valves of *L. ovatus* in the literature and the brachial valves of the Paradise representatives are in nearly every case strongly and evenly curved but not geniculate. Thus the broad spreading Pennsylvanian *L. cora* group, with geniculate brachial valve, may in many cases be distinguished from the more transversely convex (65, p. 134) Mississippian *L. ovatus* type, in which the brachial valve is seldom geniculate.

*Horizon.*—Second to Eighth members.

## Family ORTHIDAE

### Genus RHIPIDOMELLA Oehlert

#### RHIPIDOMELLA BURLINGTONENSIS (Hall)

*Orthis michelini* var. *burlingtonensis* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 596, pl. 12, figs. 4*a*, *b*, Burlington limestone.

*Rhipidomella burlingtonensis* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 149, pl. 21, figs. 5–7, pl. 83, figs. 7–8, Burlington limestone.

Excellent specimens of a large *Rhipidomella* are identified with this species. They conform closely in size, shape, and ornamentation. *R. arkansana* Girty from the Moorefield shale is closely related but differs in its proportionately broader outline and less prominent umbo. The Paradise form is believed to be identical with Hall's species in spite of the difference in range and the absence of specimens showing the muscle impressions.

*Horizon.*—Fourth member.

RHIPIDOMELLA DUBIA (Hall)

*Orthis dubia* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 12, St. Louis limestone, Spergen Hill; *1883*, Geol. Survey Indiana, 12th Rep., p. 324, pl. 29, figs. 1–5, St. Louis group.

*Rhipidomella dubia* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 160, pl. 20, figs. 22–26, Keokuk, Warsaw, and Salem; *1920*, Illinois Geol. Survey, Bull. 41, p. 351, pl. 8, figs. 5, 6, Keokuk, Warsaw, Spergen, St. Louis, and Ste. Genevieve.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 57, figs. 9–11, Warsaw, St. Louis, and Ste. Genevieve.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 278, pl. 38, figs. 3*a–c*, Keokuk to Ste. Genevieve.

This form is identical with Hall's types in every detail. It occurs as separate valves weathering from gray thin-bedded limestone.

*Horizon.*—Second member.

## Family PENTAMERIDAE

### Genus CAMAROPHORIA King

CAMAROPHORIA EXPLANATA (McChesney)
Plate 82, Figures 5*a*, *b*

*Rhynchonella explanata* MCCHESNEY, *1860*, Description New Paleozoic Fossils, p. 50, Kaskaskia limestone; *1865*, Illustr. New Spec. Fossils, pl. 6, figs. 7*a–c*.

*Camarophoria explanata* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 173, pl. 22, figs. 46–51, Chester group; *1920*, Illinois Geol. Survey, Bull. 41, p. 360, pl. 9, figs. 35–36, Golconda limestone.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—GIRTY, *1927*, U. S. Geol. Survey, Prof. Paper 152, pl. 25, figs. 85–91, Brazer limestone.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 286, pl. 42, figs. 7*a–d*, Golconda to Kinkaid.

This species is abundantly represented by excellent specimens. The shells are strongly dwarfed in several horizons but all agree closely with Weller's (1914) description and figures.

*Horizon.*—Fifth to Seventh members.

## Family RHYNCHONELLIDAE

### Genus CAMAROTOECHIA Hall and Clarke

CAMAROTOECHIA MUTATA (Hall)

*Rhynchonella mutata* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 10, St. Louis limestone; *1883*, Geol. Survey Indiana, 12th Rep., p. 332, pl. 29, figs. 43–45, St. Louis group.

*Camarotoechia mutata* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 181, pl. 24, figs. 41–60, Salem limestone.

This species is not abundant, but a number of good specimens are at hand. All are very close to the smaller individuals figured by Weller (1914). Variation occurs in the number of plications, particularly those of the fold and sinus.

*Horizon.*—Second member.

CAMAROTOECHIA PURDUEI Girty?
Plate 81, figures 8*a*, *b*

*Camarotoechia purduei* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 219, Fayetteville shale; *1911*, U. S. Geol. Survey, Bull. 439, p. 60, pl. 5, figs. 5, 5*a*, Moorefield shale; *1915*, U. S. Geol. Survey, Bull. 593, p. 59, pl. 4, fig. 5, Batesville sandstone.

A peculiar rhynchonellid is very abundant in a single narrow zone about 8 feet below the main oolite. The specimens are very variable, many conforming to *C. purduei* itself while others approach the varieties *inflata* and *laxa*. Besides these forms there are many specimens which have three plications on the fold as shown by the figured specimen. The Paradise form also resembles *Pugnoides parvulus* Girty (26) from the Brazer limestone. Girty (personal communication April, 1934), informs the writer that the Idaho form is not punctate but that the Arkansas form might

show this structure if properly preserved. This feature is important for the Arizona species is minutely but distinctly punctate, the structure being well seen in the fibrous layer where the punctations are accentuated by limonite stains. The Arizona form is distinct from *Rhynchopora(?) perryensis* Weller, and hence it is not possible to refer it definitely at this time, but it seems to conform most closely to Girty's Arkansas species.

*Horizon.*—Fourth member.

### Genus PUGNOIDES Weller

#### PUGNOIDES OTTUMWA (White)?

Plate 81, figure 4

*Rhynchonella ottumwa* WHITE, *1862*, Boston Soc. Nat. Hist., Proc., vol. 9, p. 23, St. Louis limestone; *1880*, Cont. to Invertebrate Paleontology, no. 8, p. 165, pl. 41, figs. 5*a–c*, St. Louis group.

*Pugnoides ottumwa* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 193, pl. 25, figs. 7–17, Ste. Genevieve limestone; *1916*, Walker Mus., Univ. Chicago, Cont., vol. 1, p. 246, pl. 16, figs. 7, 8, Ste. Genevieve limestone; *1920*, Illinois Geol. Survey, Bull. 41, p. 351, pl. 8, figs. 1–4, Ste. Genevieve limestone.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 278, pl. 38, figs. 5*a*, *b*, Ste. Genevieve.

The specimens thus identified are of two types. Ventral valves and poor brachial valves from the Second member are almost certainly identical with the eastern species. Specimens from the Third member are smaller, more convex, and have rounder plications than *P. ottumwa;* they probably represent a distinct variety but are too poor to describe.

*Horizon.*—Second and Third members.

## Family TEREBRATULIDAE

### Genus DIELASMOIDES Weller

#### DIELASMOIDES BISINUATUS Weller

Plate 82, figures 4*a*, *b*

*Dielasmoides bisinuata* WELLER, *1911*, Jour. Geol., vol. 19, p. 443, figs. 3*a–g*, St. Louis? oolite; *1914*, Illinois Geol. Survey, Mon. 1, p. 254, pl. 21, figs. 19–24, Patrick's Quarry, Middle Fabius River, Lewis County, Mo.

This distinctive species is extremely abundant in the collections. The internal structure in many individuals is obscured by coarsely crystalline calcite, but others show the features characteristic of the genus.

Specimens identical with Weller's types are common, but others are longer and narrower than the typical shells. Occasional specimens are rather convex, and in such cases the bisinuate character is very pronounced. Ordinarily the bisinuate character of the shell is not developed until a length of 10 to 12 mm. is attained.

*Horizon.*—Rare in the Third member, abundant in the Second member.

### Genus DIELASMA King

#### DIELASMA SHUMARDANUM (Miller)

*Terebratula arcuata* SWALLOW, *1863*, St. Louis Acad. Sci., Trans., vol. 2, p. 83 (not *T. arcuata* Roemer, 1840), Kaskaskia limestone.

*Terebratula shumardana* MILLER, *1883*, American Paleozoic Fossils, 2d ed., p. 299.

*Dielasma shumardanum* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 268, pl. 31, figs. 25–27, Chester group, Okaw formation.

The genus *Dielasma* is abundantly represented by very poor specimens. Generally the shells are fragmentary and disarticulated or badly crushed. However, a few specimens show the narrow sinus originating at the beak and the anterior position of the greatest width characteristic of *D. shumardanum.* Other fragmentary specimens resemble *D. formosum*, *D. arkansanum*, and *D. illinoisensis*, but cannot be satisfactorily referred.

*Horizon.*—Fifth to Seventh members.

### Genus GIRTYELLA Weller

#### GIRTYELLA BREVILOBATA (Swallow)

*Terebratula brevilobata* SWALLOW, *1863*, St. Louis Acad. Sci., Trans., vol. 2, p. 84, *Archimedes* limestone.

*Dielasma turgida* var. *elongata* WELLER, *1897*, New York Acad. Sci., Trans., vol. 16, p. 260, pl. 18, fig. 6, Batesville sandstone.

*Harttina brevilobata* var. *marginalis* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, no. 3, p. 219, Fayetteville shale.

*Harttina brevilobata* GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 65, pl. 2, figs. 12, 12*a*, Moorefield shale.

*Girtyella brevilobata* S. WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 278, pl. 34, figs. 37–41, Chester group.—J. M. WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. 4*a–c*, Ste. Genevieve and Chester.

*Girtyella turgida* var. *elongata* GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 62, pl. 5, figs. 2–3*a*, Batesville sandstone.

A number of small specimens are assigned to this species. They are typical in outline, convexity, and in the trilobation of the anterior border, but the mesial sinus of the pedicle valve is not as strongly developed as in the Mississippi Valley form, probably because of their smaller size. A few specimens from near the top of the formation are included, but they seem to be merely variants of *G. indianensis*.

*Horizon.*—Second(?), Third, Fourth (?), Fifth(?) and Seventh members.

GIRTYELLA INDIANENSIS (Girty)
Plate 81, figure 5

*Harttina indianensis* GIRTY, *1908*, U. S. Nat. Mus., Proc., vol. 34, p. 293, pl. 19, figs. 6–15.

*Girtyella indianensis* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 275, pl. 34, figs. 1–24, Ste. Genevieve, Chester; *1916*, Walker Mus., Univ. Chicago, Cont., vol. 1, p. 246, pl. 16, figs. 9, 10, Ste. Genevieve.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

The specimens thus identified are rather variable, but the average shells agree closely with the types. Many specimens are dwarfed. Variation occurs in three ways. A few small individuals are conformable to *G. turgida* but are less convex. Others approach *G. brevilobata*, but the trilobation is not as prominent. Still others are broader and more convex than normal *G. indianensis*, probably the form that Girty (14) described as the variety *exporrecta*. All the varieties mentioned are associated with more abundant specimens of normal *G. indianensis*, into which they grade and are hence not separated here.

*Horizon.*—Fourth to Seventh members.

## Family SPIRIFERIDAE

### Genus SPIRIFERINA d'Orbigny

SPIRIFERINA SPINOSA (Norwood and Pratten)

*Spirifer spinosus* NORWOOD and PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 71, pl. 9, figs. 1*a–d*, top Mountain limestone.

*Spiriferina cristata* WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 218, pl. 18, fig. 13, Lower and Upper Carboniferous, Eureka, Nevada.

*Spiriferina spinosa* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 299, pl. 35, figs. 50–58, Chester group.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 66, pl. 4, fig. 9, Batesville sandstone.—WELLER, *1920*, Illinois Geol. Survey, Bull. 41, p. 353, pl. 8, figs. 15, 16, Paint Creek formation.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 65, figs. 18–19, Gasper formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. 3*a–c*, Ste. Genevieve and Chester.

Well preserved specimens are rare, but the species occurs at several horizons in abundance. The individuals are rather variable, one type being so well marked as to be separated as a variety. The form identified with *S. spinosa* itself comprises rather dwarfish specimens with subangular to rounded plications. The pustules as preserved are small and rather closely set.

A few specimens from the Stoyanow collections differ from normal *S. spinosa* in their small depressed and well rounded plications, of which there are about ten on each lateral slope. The sinus is shallow, broadly rounded, and widens rapidly toward the anterior margin.

*Horizon.*—Sixth and Seventh members.

SPIRIFERINA SPINOSA var. COCHISENSIS
Hernon, n. var.
Plate 82, figure 1

*Spiriferina spinosa* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

An abundant form of *Spiriferina* has features which make a distinctive name desirable. Externally the form mimics *S. transversa* so closely that it is difficult to believe that the two are distinct.

The outline is alate; the plications are rounded to somewhat angular and number 10 to 12 on each lateral slope. The fold and sinus are respectively modified by a mesial furrow and ridge which begin at about the mid-length and extend to the anterior border. The surface is marked by rather closely set pustules and the shell structure is punctate.

The form probably represents a new species but is given a varietal name at this time. It occurs alone and has not been seen to grade into *S. spinosa* itself. Snider (48, p. 93) mentions a form from the Chester of Oklahoma which is apparently the same as the one under discussion.

The new variety is easily distinguished from *S. transversa* by the pustules present on the non-exfoliated surface.

*Horizon.*—Fifth(?) and Seventh members.

SPIRIFERINA TRANSVERSA (McChesney)

*Spirifer transversa* McCHESNEY, *1860*, Description New Paleozoic Fossils, p. 42, Kaskaskia limestone; *1865*, Illustr. New Spec. Fossils, pl. 6, figs. *3a–c*.

*Spiriferina transversa* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 297, pl. 35, figs. 41–49, Chester group.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 68, pl. 4, fig. 10, Batesville sandstone.—WELLER, *1920*, Illinois Geol. Survey, Bull. 41, p. 353, pl. 8, figs. 17, 18, Chester.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 65, figs. 20–23, Gasper formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. *2a–c*, Ste. Genevieve and Chester.

Good specimens of this species are not common, but a few individuals lack pustules on the non-exfoliated surface and have the median plication of the fold and sinus.

*Horizon.*—Fifth and Seventh members.

Genus SPIRIFER Sowerby

SPIRIFER ARIZONENSIS Hernon, n. sp.
Plate 82, figures *2a–c*

Shell of medium size; width usually exceeding the length but sometimes subequal and greatest at the hinge-line; the cardinal extremities rectangular or moderately attenuate. The dimensions of three pedicle valves are: length 19 mm., 23 mm., and 28 mm.; width 26 mm., 27 mm., and 35 mm.; convexity 8 mm., 9 mm., and 11 mm. Dimensions of the best brachial are: length about 19 mm., and width about 27 mm.

Pedicle valve moderately convex, the greatest convexity near the umbonal region, the umbo high and the beak pointed and incurved; cardinal area concave, its height about 3 mm. for the average size individual; lateral slopes of valve plane or slightly concave transversely (rarely slightly convex) and somewhat compressed near the cardinal extremities, curving rather abruptly to the cardinal margin but with very low convexity to the antero-lateral borders; surface of each lateral slope marked by from ten to fourteen, usually eleven, simple rounded plications which are fainter toward the cardinal extremities; mesial sinus originating at the beak, angular and well defined at first but less so anteriorly, widening slowly from beak to anterior border; sinus occupied by a single plication near the beak which grows in strength anteriorly; on either side of the median plication is a single plication of equal strength which originates from the inner margin of the bounding plications of the sinus; the plications of the sinus are smaller than those of the lateral slopes.

Brachial valve about as convex as the pedicle valve, greatest convexity at or posterior to the mid-length, the surface sloping rather abruptly to the cardinal margin and curving convexly to the compressed cardinal extremities; mesial fold well defined at the beak becoming elevated above the general level anteriorly; marked by a narrow median furrow with a second furrow on either side; lateral slopes marked by plications similar to those of the opposite valve, except that the second lateral plication originates by bifurcation of the third near the beak.

When well preserved the entire surface is marked by very fine concentric and radial lines which give it a finely reticulated appearance. Lines of growth are usually weak or obsolete.

*Remarks.*—This species is most nearly allied to *S. pellaensis* of the Mississippi Valley but differs in its elevated umbo, the high pentagonal shape, the narrow sinus with plications of equal strength, and the plane or slightly concave lateral slopes of the pedicle valve. It may be readily distinguished from the form *S. pellaensis* var. *cavecreekensis* by the smaller rounder plications, the high umbo and high pentagonal outline, the plane or concave lateral slopes of the pedicle valve, and by the less rapidly widening sinus. The valves of this species are always separate with the exception of a few young individuals, and while many hundreds of fair pedicle valves were collected, the writer has been unable to obtain a single good brachial valve.

*Horizon.*—Fourth to Sixth members.

### Spirifer bifurcatus Hall

*Spirifer bifurcata* Hall, *1856*, Albany Inst., Trans., vol. 4, p. 8, St. Louis limestone; *1883*, Geol. Survey Indiana, 12th Rep., p. 326, pl. 29, figs. 13–15, St. Louis group.—Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 346, pl. 47, figs. 6–16, Salem limestone.—Stoyanow, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—Butts, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 57, figs. 1–4, Warsaw formation.

This is an abundant species in the collections. Some typical specimens are found as high as the main oolite, where they appear to grade into *S. leidyi*. The specimens average larger than Hall's types, though dwarfed in some horizons. Some individuals have a somewhat shallower furrow on the fold than the Mississippi Valley form.

*Horizon.*—Second to Fifth members.

### Spirifer leidyi Norwood and Pratten

*Spirifer leidyi* Norwood and Pratten, *1855*, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 72, pl. 9, figs. 2*a–c*, upper Mountain limestone.—(?) Walcott, *1884*, U. S. Geol. Survey, Mon. 8, p. 216, pl. 18, figs. 4, 4*a*, Lower Carboniferous, Eureka, Nevada.—Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 345, pl. 47, figs. 17–31, Chester group.—Stoyanow, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

Poorly preserved specimens of this species are abundant in the upper half of the Paradise formation. The specimens vary in character of the fold and sinus between *S. leidyi* and *S. bifurcata*. Some individuals have the plications somewhat more angular than is typical but this feature may be due to exfoliation.

*Horizon.*—Third to Seventh members.

### Spirifer pellaensis Weller

*Spirifer keokuk* var. Hall, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 676, pl. 24, figs. 4*a–d*, St. Louis limestone.

*Spirifer pellaensis* Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 340, pl. 45, figs. 1–31, Pella beds of the Ste. Genevieve.—Butts, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 61, figs. 6–8, Gasper formation.—Weller, *1931*, Kentucky Geol. Survey, Symposium, p. 278, pl. 38, figs. 1*a*, *b*, Ste. Genevieve.

This species is rare in the collections, but specimens conforming exactly to the high form figured by Weller (1914, figs. 21, 26) are at hand. It differs in several ways from *S. arizonensis* but may be most easily distinguished by the transverse convexity of the pedicle valve on either side of the sinus. The two species do not occur together.

*Horizon.*—Third member.

### Spirifer pellaensis var. cavecreekensis Hernon, n. var.

Plate 82, figures 3*a*, *b*

*Spirifer* aff. *S. pellensis* Girty, *1927*, U. S. Geol. Survey, Prof. Paper 152, pl. 24, figs. 9–11, Brazer limestone.

This form is similar to both *S. pellaensis* and *S. increbescens*. It differs from the former in its elevated umbo and higher area and particularly in the nature of the plications of the sinus which are of equal strength in the Arizona form.

From *S. increbescens* it is distinguished by the higher umbo and the lesser number of lateral plications, there being 9 to 12 in the Arizona form as compared to 14 to 18 in the Mississippi Valley species.

*Horizon.*—Sixth and Seventh members.

### Genus BRACHYTHYRIS McCoy

#### BRACHYTHYRIS CHESTERENSIS Butts

*Brachythyris chesterensis* BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 61, figs. 9–12, Gasper formation.

*Brachythyris laticosta* and *Brachythyris subcardiiformis* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

Compare *Brachythyris ozarkensis* SNIDER, 1915, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 90, pl. 5, figs. 3–6, Fayetteville formation.

A well-defined, narrow but continuous zone in the main oolite yields abundant specimens of this species. The species is closely related to *B. laticosta* Mather, but differs in having 4 plications on the fold rather than "about three," 5 to 7 lateral plications as compared to 8 to 10, and a somewhat different outline. Nevertheless, *B. laticosta* and *B. chesterensis*, and *B. ozarkensis* are a distinctive group characterized by very low broad plications and an acutely pointed beak. The writer is not at all sure but that *B. chesterensis* and the Arizona forms belong in the synonomy of *B. ozarkensis*, for the small or immature Paradise individuals conform very closely to Snider's species, whereas the associated mature or large forms are identical with the Alabama species. For the present, however, the Arizona specimens are referred to *B. chesterensis*.

*Horizon.*—Fifth member.

### Genus RETICULARIA McCoy

#### RETICULARIA SETIGERA (Hall)

*Spirifer setigerus* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 705, pl. 27, figs. 4*a*, *b*, Kaskaskia limestone.—HALL and WHITFIELD, *1877*, U. S. Geol. Survey, 40 Par., vol. 4, p. 270, pl. 5, figs. 17–18, Lower Carboniferous limestone.

*Reticularia setigera* GIRTY(?), *1915*, U. S. Geol. Survey, Bull. 593, p. 65, pl. 4, fig. 6, Batesville sandstone.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 9*a*, *b*, Ste. Genevieve and Chester.

This well known species is abundant in the Paradise formation. Specimens from the main oolite are of normal size but others from higher horizons are dwarfed; the dwarfed type exhibits the specific characters clearly.

*Horizon.*—Fifth to Seventh members.

### Genus EUMETRIA Hall

#### EUMETRIA VERA (Hall)

*Retzia vera* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 704, pl. 27, fig. 3*a*, Kaskaskia limestone.

*Eumetria vera* S. WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 444, pl. 76, figs. 13–17, Chester group.—J. M. WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. 7*a*, *b*, Chester.

*Eumetria marcyi* GIRTY (part), *1915*, U. S. Geol. Survey, Bull. 593, p. 75, pl. 4, figs. 19–19*b*, Batesville sandstone.

The shape of the shell and the number of costae are used in differentiating this form from *E. verneuilana*.

*Horizon.*—Fourth to Eighth members.

#### EUMETRIA VERNEUILANA (Hall)

*Retzia verneuilana* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 9, St. Louis limestone; *1858*, Geol. Iowa, vol. 1, pt. 2, p. 657, pl. 23, figs. 1*a–d*, Warsaw limestone.

*Eumetria verneuilana* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 442, pl. 26, figs. 18–24, Salem, St. Louis, Chester.

*Eumetria marcyi* GIRTY (part), *1915*, U. S. Geol. Survey, Bull. 593, p. 75, pl. 4, fig. 18, Batesville sandstone.

*Eumetria verneuilana* STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 278, pl. 38, figs. 7*a*, *b*, Salem to lower Chester.

This well known species is abundant in the collections in association with *E. vera*. The association with *E. vera* is a constant feature suggesting that the two represent a single varied species, but it is possible to select types conforming to both of Hall's species and hence the specimens have been separated. Both

types are greatly varied in proportion of length to width, convexity, and size.

*Horizon.*—Third to Sixth, and Seventh (?) members.

## Family ATHYRIDAE

### Genus CLIOTHYRIDINA Buckman

#### CLIOTHYRIDINA SUBLAMELLOSA (Hall)

*Athyris sublamellosa* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 702, pl. 27, figs. 1*a–c*, Kaskaskia limestone.

*Cliothyridina sublamellosa* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 482, pl. 80, figs. 31–60, Ste. Genevieve limestone and Chester.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 69, pl. 4, figs. 11–13, Batesville sandstone.—WELLER, *1920*, Illinois Geol. Survey, Bull. 41, p. 354, pl. 8, figs. 21–24, Ste. Genevieve to middle Chester.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 284, pl. 41, figs. 14*a*, *b*, Ste. Genevieve and Chester.

A small *Cliothyridina* is abundant in the main oolite and is common near the top of the Paradise formation as strongly dwarfed specimens. On the whole the form conforms closely to *C. hirsuta*, but some individuals attain a somewhat larger size than that species. The convexity of the valves is about equal, a character of *C. hirsuta* but also a character of small specimens of *C. sublamellosa*, as pointed out by Weller (1914). The whole group is here assigned to *C. sublamellosa* but many specimens could as well be identified with *C. hirsuta*. Nearly all the specimens are exfoliated but a few retain the flattened spines and the others show traces of them.

*Horizon.*—Second(?) and Fourth to Seventh members.

### Genus COMPOSITA Brown

#### COMPOSITA DELTOIDES Hernon, n. sp.

Plate 82, figures 6*a–d*

Shell small, the width equal or usually slightly greater than the length, rounded triangular in outline, the greatest width well anterior to the mid-length. The dimensions of three typical specimens are: length 10.5 mm., 7 mm., and 6 mm.; width 11 mm., 8 mm., and 7 mm.; thickness 5.5 mm., 4.5 mm., and 4 mm.

Pedicle valve most convex posterior to the middle, the surface curving abruptly from the umbo to the cardinal margin but only slightly to the lateral margins at the points of greatest width. Mesial sinus slightly developed after a length of 5 mm. had been attained by the shell; lateral slopes from sinus moderately convex; the beak incurved and perforated by a small foramen.

Brachial valve subequally or slightly more convex than the pedicle, most convex posterior to the middle and near the anterior border; lateral convexity greatest posteriorly and the mesial fold obsolete. Beak strongly incurved beneath that of the opposite valve.

As preserved most specimens are partly exfoliated and are smooth.

*Remarks.*—This dwarfish species differs from all others of the genus known to the writer in its triangular shape resulting from the anterior position of the greatest width. Some specimens are extremely truncated at the anterior margin.

*Horizon.*—Fourth and Fifth members.

#### COMPOSITA LAEVIS Weller

*Composita laevis* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 491, pl. 82, figs. 14–20, Chester group.

This species is represented by typical specimens, though never abundant. Some individuals approach *C. lewisensis* Weller.

*Horizon.*—Fourth, Fifth, Sixth(?), and Seventh members.

#### COMPOSITA cf. C. OZARKANA Mather

*Composita ozarkana* MATHER, *1915*, Sci. Lab Denison Univ., Bull., vol. 18, p. 498, pl. 13, figs. 11–15*c*, Morrow group.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

A species of *Composita* represented by numerous dwarfish specimens is thus identified. The specimens seldom exceed a length of 13 mm., the outline is rounded-subquadrate, and non-exfoliated specimens have a faint median fur-

row in the sinus. Smaller individuals are nearly circular in outline. It is possible that the form is really a dwarf of *C. subquadrata* or of the subquadrate type of *C. trinuclea*. Average specimens conform closely to Mather's figures 14 and 14*a*.

*Horizon.*—Fourth to Seventh members.

COMPOSITA TRINUCLEA (Hall)

*Terebratula trinuclea* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 7, St. Louis limestone; *1858*, Geol. Iowa, vol. 1, pt. 2, p. 659, pl. 23, figs. 4*a–c*, 5, Warsaw limestone.

*Composita trinuclea* WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 486, pl. 81, figs. 16–45, Salem to Chester; *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 246, pl. 16, figs. 3–6, Ste. Genevieve limestone; *1920*, Illinois Geol. Survey, Bull. 41, p. 354, pl. 8, figs. 19, 20; pl. 9, figs. 37, 38, Spergen to middle Chester.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.—BUTTS, *1926*, Geol. Alabama, Alabama Geol. Survey, pl. 61, figs. 4, 5, Gasper formation.—WELLER, *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 5*a*, *b*, Salem to Chester.

A few specimens of a dwarfish *Composita* are very close to the narrow individuals figured by Weller (1914). The Paradise form is small, high, rather convex, and does not have the fold and sinus sharply differentiated from the lateral slopes.

*Horizon.*—Second, Fourth to Sixth, and Seventh(?) members.

## PELECYPODA

### Family GRAMMYSIIDAE

### Genus EDMONDIA DeKoninck

EDMONDIA GENEVIEVENSIS Weller

*Edmondia genevievensis* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 247, pl. 16, fig. 2, Ste. Genevieve.

Well preserved specimens of this species average slightly smaller than the type but are otherwise typical.

*Horizon.*—Third and Fifth members.

### Family NUCULIDAE

### Genus NUCULA Lamarck

NUCULA ILLINOISENSIS Worthen

*Nucula illinoisensis* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 15, St. Louis oolitic beds; *1890*, Illinois Geol. Survey, vol. 8, p. 128, pl. 19, figs. 4, 4*a*, St. Louis oolitic limestone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 248, pl. 17, figs. 5, 6, Ste. Genevieve.

*Nucula levatiforme* WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 241, pl. 22, figs. 1, 1*a*, Lower Carboniferous, Eureka, Nevada.

Good specimens of this species are not common but there can be little doubt as to the reference.

*Horizon.*—Third member.

### Family LEDIDAE

### Genus LEDA Schumacher

LEDA CURTA Meek and Worthen

*Leda curta* MEEK and WORTHEN, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 144, St. Louis limestone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 248, pl. 17, figs. 11, 12, Ste. Genevieve.

*Nuculana? curta* MEEK and WORTHEN, *1866*, Illinois Geol. Survey, vol. 2, p. 283, pl. 20, figs. 6*a*, *b*, St. Louis group.

This species is abundant but most specimens are exfoliated. A few, however, show the typical outline and ornamentation.

*Horizon.*—Third member.

### Family PARALLELODONTIDAE

### Genus PARALLELODON Meek

PARALLELODON MINIMA (Worthen)

*Pleurophorus minimus* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 17, St. Louis oolitic beds; *1890*, Illinois Geol. Survey, vol. 8, p. 124, pl. 20, figs. 4, 4*a*, St. Louis oolitic limestone.

*Parallelodon minima* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 248, pl. 17, fig. 7, Ste. Genevieve.

Excellent specimens of this little species are identical with Worthen's figured type.

*Horizon.*—Fifth member.

### Family PTERINEIDAE

### Genus LEPTODESMA Hall

LEPTODESMA ROBUSTUM Girty

Plate 82, figure 8

*Leptodesma spergenense* var. *robustum* GIRTY,

*1915*, U. S. Geol. Survey, Bull. 593, p. 89, pl. 7, figs. 2, 3, Batesville sandstone.

A number of specimens from the Paradise formation conform so closely to Girty's variety that the writer is unable to separate them. The form is much larger than *L. spergenense*, is less oblique, and has the oblique constriction characteristic of *L. spergenense* var. *robustum*. Dwarfish specimens can likewise be distinguished from the Spergen form. A single specimen associated with the others is very like or identical with *L. carboniferum* Girty. The form is so well characterized that it is here raised to full specific rank.

*Horizon.*—Third and Fifth(?) members.

## Family MYALINIDAE

### Genus MYALINA deKoninck

#### MYALINA ANGULATA Meek and Worthen

*Myalina angulata* MEEK and WORTHEN, *1860*, Acad. Nat. Sci. Philadelphia, Proc., p. 455, Chester limestone; *1866*, Illinois Geol. Survey, vol. 2, p. 300, pl. 23, figs. 7*a*, *b*, Chester group.

The specimens thus identified are identical with the Mississippi Valley type in every detail except size, being much smaller. No specimens of normal size have been found.

*Horizon.*—Fifth and Seventh members.

#### MYALINA CONGENERIS Walcott

*Myalina congeneris* WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 237, pl. 22, fig. 10; not pl. 19, fig. 6, lower part of the Carboniferous group, Eureka, Nevada.

Large partly exfoliated specimens are thus identified. The two specimens figured by Walcott apparently represent two species. That figured on Plate 22 has the more acutely pointed beak and has the greatest convexity along a zone from the beak to the postero-ventral margin, thus differing from the specimen of Plate 19 which has the greatest convexity bordering the anterior margin.

*Horizon.*—Third member.

#### MYALINA MONROENSIS Worthen

*Myalina monroensis* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 15, St. Louis oolitic beds; *1890*, Illinois Geol. Survey, vol. 8, p. 127, pl. 20, figs. 10, 10*a*, St. Louis oolitic limestone.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 96, pl. 6, figs. 6, 6*a*, Batesville sandstone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 250, pl. 16, fig. 18, Ste. Genevieve.

This is one of the abundant species of the Paradise formation. Average specimens are very close to Worthen's but some have the imperfect parallelogram shape noted by Girty among the Batesville forms.

*Horizon.*—Third member.

#### MYALINA PORTALENSIS Hernon, n. sp.

Plate 82, figures 9*a*, *b*

Left valve of medium size or larger, the dimensions of two specimens being: height 35 mm. and 20 mm., greatest length 24 mm. and 14 mm., greatest convexity 9 mm. and 6 mm.

Shape of convex portion rounded-triangular, outline somewhat subquadrate, the hinge-line being almost at right angles to the anterior margin. Shell rather convex, the locus of greatest convexity extending from the beaks to the mid-portion of the ventral margin. Beak elevated above the hinge-line, somewhat incurved, and very acutely pointed. Region posterior to the beak compressed near the postero-dorsal margin but rounding into the convex portion of the valve anteriorly and ventrally. Right valve unknown.

As preserved the ornamentation is not well seen but traces of strong lines of growth are present and are from 2 to 3 mm. apart.

*Horizon.*—The specimens are mostly from the Stoyanow collections. Judging from the matrix the horizon belongs either to the Third, Fourth or Fifth members. Also from the Third member in my collections.

## Family TRIGONIIDAE

### Genus SCHIZODUS King

#### SCHIZODUS CHESTERENSIS Meek and Worthen

*Schizodus chesterensis* MEEK and WORTHEN,

*1860*, Acad. Sci. Philadelphia, Proc., p. 457, upper Chester limestone; *1866*, Illinois Geol. Survey, vol. 2, p. 301, pl. 23, figs. 6*a*, *b*, Chester group.—MORSE, *1911*, Ohio Acad. Sci., Proc., vol. 5, pt. 7, sp. paper 17, p. 390, fig. 16, Maxville limestone, upper zone.

There seems to be no difference between the Paradise representatives and Worthen's figured type except that the beaks of the Arizona form are not as highly incurved.

*Horizon.*—Fifth member.

SCHIZODUS DEPRESSUS Worthen

*Schizodus depressus* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 11, St. Louis oolitic beds; *1890*, Illinois Geol. Survey, vol. 8, p. 109, pl. 18, figs. 8, 8*a*, St. Louis oolitic limestone.—(?)WELLER, *1897*, New York Acad. Sci., Trans., vol. 16, p. 267, pl. 21, figs. 7, 8 (date volume 1898), Batesville sandstone.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 98, pl. 9, fig. 7; Worthen's type refigured figs. 13, 13*a*, Batesville sandstone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 250, pl. 16, figs. 25–27, Ste. Genevieve.

This species is common in the collections. Some specimens are typical in form but others conform to Girty's variety *abruptus* from the Batesville sandstone. There seems to be complete gradation between the two types among the Paradise forms.

*Horizon.*—Third member.

## Family PECTENIDAE

### Genus DELTOPECTEN Etheridge

DELTOPECTEN MONROENSIS (Worthen)

*Aviculopecten monroensis* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 21, St. Louis oolitic beds; *1890*, Ill. Geol. Survey, vol. 8, p. 114, pl. 22, figs. 8, 8*a*, 8*b*?, St. Louis oolitic limestone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 250, pl. 16, figs. 13–15, Ste. Genevieve.

Specimens from the Third member are entirely typical of Worthen's species, while others from the Fifth member are larger than that species on the average and may represent a distinct form. They are not separated here, however. The ornamentation is distinctly of the alternating type, distinguishing the form from Weller's species *D. batesvillensis* as figured by Girty (16) from the Batesville sandstone.

*Horizon.*—Third and Fifth members.

### Genus STREBLOPTERIA McCoy

STREBLOPTERIA SIMPLICIFORMIS Girty

*Streblopteria simpliciformis* GIRTY, *1927*, U. S. Geol. Survey, Prof. Paper 152, p. 419, pl. 25, figs. 51–55, Brazer limestone.

This little species is represented by numerous partly exfoliated specimens. A larger size is sometimes attained than the types figured by Girty, but otherwise they agree so closely that separation is not necessary.

A number of specimens associated with typical forms differ in being considerably larger, they have a larger apical angle, and particularly differ in that the anterior ear extends almost as far as the main body of the shell. This form may be a distinct variety.

*Horizon.*—Third member.

## Family MYTILIDAE

### Genus MODIOLA Lamarck

MODIOLA FOUNTAINENSIS Weller

*Modiola fountainensis* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 251, pl. 16, fig. 19, Ste. Genevieve limestone.

This speci[illegible]ssociated with specimens that approach *M. illinoiensis* but are scarcely typical. The type *M. fountainensis* predominates over the other, and occasional specimens intermediate between the two are found. *Lithophagus* (?) *batesvillensis* Weller closely approaches this species in shape.

*Horizon.*—Fifth member.

MODIOLA ILLINOIENSIS Worthen

Plate 82, figure 7

*Modiola illinoiensis* WORTHEN, *1884*, Illinois State Mus. Nat. Hist., Bull. 2, p. 16, St. Louis oolitic beds; *1890*, Illinois Geol. Survey, vol. 8, p. 125, pl. 20, figs. 2, 2*a*, St. Louis oolitic limestone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 251, pl. 16, figs. 16, 17, Ste. Genevieve.—

STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317, Paradise formation.

*Myalina illinoisensis* GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 94, pl. 6, figs. 4, 5, Batesville sandstone.

Abundant specimens of this species are present in the collections. Considerable variation in size and outline occurs, but average specimens conform closely to the Mississippi Valley form.

The figured individual, from the third member, is of the type found in the Batesville sandstone as figured by Girty (1915, fig. 5).

*Horizon.*—First(?), Second, Third and Fifth members.

## GASTROPODA

### Family BELLEROPHONTIDAE

#### Genus BELLEROPHON Montfort

##### BELLEROPHON SUBLAEVIS Hall

*Bellerophon sublaevis* HALL, *1856*, Albany Inst., Trans., vol. 4, p. 32, St. Louis limestone; *1883*, Indiana Geol. Survey, 12th Rep., p. 371, pl. 31, figs. 6, 7, St. Louis group.—WELLER, *1897*, New York Acad. Sci., Trans., vol. 16, p. 269, pl. 20, fig. 10, Batesville sandstone.—MORSE, *1911*, Ohio Acad. Sci., Proc., vol. 5, sp. paper 17, p. 404, figs. 29*a*, *b*, Maxville limestone.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 257, pl. 19, figs. 11, 12, Ste. Genevieve.

The shells thus identified average about 15 to 20 mm. in diameter and agree closely with Hall's form.

*Horizon.*—Fifth member.

#### Genus BUCANOPSIS Ulrich

##### BUCANOPSIS MONROENSIS (Weller)

*Bellerophon monroensis* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 257, pl. 19, figs. 7, 8, Ste. Genevieve.

This little species is identical in every way with Weller's form except that it shows traces of the reticulate ornamentation on various parts of the shell and is hence referred to *Bucanopsis*, a reference suspected by Weller.

*Horizon.*—Third member.

#### Genus EUPHEMUS McCoy

##### EUPHEMUS LENTIFORMIS Weller

*Euphemus lentiformis* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 258, pl. 19, figs. 9, 10, Ste. Genevieve.

This little species is represented by numerous specimens that average slightly smaller than the types.

*Horizon.*—Third member.

### Family EUOMPHALIDAE

#### Genus STRAPAROLLUS Montfort

##### STRAPAROLLUS SIMILIS var. PLANUS Meek and Worthen

*Straparollus similis* var. *planus* MEEK and WORTHEN, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 146, St. Louis limestone; *1866*, Illinois Geol. Survey, vol. 2, p. 286, pl. 19, figs. 5*a–c*, St. Louis group.—WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 259, pl. 17, figs. 15, 16, Ste. Genevieve.

A single collection yields typical specimens of this variety.

*Horizon.*—Third member

### Family NERITOPSIDAE

#### Genus NATICOPSIS McCoy

##### NATICOPSIS aff. N. WATERLOOENSIS Weller

*Naticopsis waterlooensis* WELLER, *1916*, Walker Mus., Univ. Chicago, Contr., vol. 1, p. 259, pl. 19, figs. 3–6, Ste. Genevieve.

This species is identical with Weller's form in every detail except size, it being about four times as large as his types. Weller's figure 3 (×4) represents the Paradise form in size and shape.

*Horizon.*—Fifth member.

### Family CAPULIDAE

#### Genus ORTHONYCHIA Hall

##### ORTHONYCHIA STRIALUTUS var. PORTALENSIS Hernon, n. var.

Plate 82, figures 10*a*, *b*

This variety may be compared with *Capulus striatulus* var. *gracilis* Girty (26, p. 431). It is three times as large,

proportionately more slender, about equally oblique, and with the beak less strongly incurved. *C. striatulus* Girty is a smaller, more oblique, and much more rapidly expanding shell. This type of shell seems to conform more closely to typical species of *Orthonychia* than to species of *Capulus*.

*Horizon.*—Fifth member.

### Genus Strophostylus Hall

#### Strophostylus splendens Girty

*Strophostylus splendens* Girty, *1915*, U. S. Geol. Survey, Bull. 593, p. 125, pl. 11, figs. 11–12*a*, Batesville sandstone.

The writer is unable to differentiate the forms thus identified from Girty's species.

*Horizon.*—Third member.

## Cephalopoda

### Family Cycloceratidae

### Genus Cycloceras McCoy

#### Cycloceras randolphensis (Worthen)

*Orthoceras annulo-costatum* Meek and Worthen, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 147 (not *O. annulato-costatum* Boll, *1857*), Chester limestone; *1866*, Illinois Geol. Survey, vol. 2, p. 304, pl. 24, figs. 3*a*, *b*, Chester limestone.

*Orthoceras randolphensis* Worthen, *1882*, Illinois State Mus. Nat. Hist., Bull. 1, p. 38, Chester group.—(?)Walcott, *1884*, U. S. Geol. Survey, Mon. 8, p. 265, pl. 18, fig. 17, Lower Carboniferous, Eureka, Nev.—Morse, *1911*, Ohio Acad. Sci., Proc., vol. 5, pt. 7, sp. paper 17, p. 414, fig. 35, Maxville limestone.

Fragmentary specimens conform closely to this species.

*Horizon.*—Fifth member.

### Family Trigonoceratidae

### Genus Stroboceras Hyatt

#### Stroboceras sp.

A single specimen is identified in this way. It is very close to *Stroboceras* sp. figured by Weller (66) from the Ste. Genevieve.

*Horizon.*—Third member.

## Arthropoda

The trilobites are represented in many horizons by pygidia and rare cranidia. Determinable specimens in the collections belong to the genus *Griffithides*, although *Phillipsia* is probably present also.

The ostracodes are very poorly represented, the few poorly preserved specimens available apparently belonging to the genus *Paraparchites*.

## Vertebrata

The vertebrates are represented by a single specimen of a fish spine, and by rather numerous specimens of shark teeth.

## Plants

Plant remains are present in at least three horizons of the Paradise formation. A specimen from the Fourth member is tentatively identified as *Stigmaria* sp. An entirely different type of plant from the Sixth member is represented by macerated specimens and is unidentified.

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# GRAPTOLITES OF THE SYLVAN SHALE OF OKLAHOMA AND POLK CREEK SHALE OF ARKANSAS

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ABSTRACT

The graptolites of the Sylvan shale of Oklahoma and some from the Polk Creek shale of Arkansas are described and illustrated. Eight species and varieties, two of which are new, and a fragment of another genus are included. The evidence seems to relate the Sylvan and Polk Creek shales closely with one another, and both of them with the upper Hartfell shales of Great Britain.

The Sylvan shale was named from the former town of Sylvan which was located on the south edge of the Arbuckle Mountains about 12 miles northwest of Ravia in the Tishomingo quadrangle of Oklahoma. Graptolites were collected from this shale by Taff (4) more than 30 years ago, and three genera were listed, but no specific determinations were made.

As practically all the graptolites of the Sylvan shale of Oklahoma are found also in the Polk Creek shale of Arkansas, the characteristics of the latter formation will be noted briefly. The Polk Creek shale was named for Polk Creek in the northwestern part of Caddo Gap quadrangle, Arkansas. Long lists of graptolites from the Polk Creek shale by Ulrich were published by Miser and Purdue (2, pp. 40, 41), but here again the determinations were largely only generic. While the graptolites of the Sylvan shale were being studied, there was not sufficient time available to make a complete study of all of the graptolites of the Polk Creek shale, which apparently contains more species than does the Sylvan shale. While a few more species were determined, the chief object here will be to include those species from the Polk Creek which occur in the Sylvan shale, and describe two new varieties from the Polk Creek.

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### DISTRIBUTION

The Sylvan shale occurs in many scattered outcrops in the Arbuckle Mountains. It extends eastward in the Black Knob Ridge east of Atoka, and east of there into the Ouachita Mountains of eastern Oklahoma, where it is thought to merge eastward into the Polk Creek shale of Arkansas. In the subsurface it extends northward to Oklahoma City, Edmond, Lucien and northeastward in Oklahoma and Kansas, where it is thought to grade northeastward into the Maquoketa shale of Iowa.

### PHYSICAL CHARACTERISTICS AND STRATIGRAPHIC RELATIONS

Except that at some localities the Sylvan shale is brown, Taff's early description fits it well (4): "The Sylvan shale except near the base, consists of greenish almost structureless clay." This clayey condition is well illustrated in an outcrop northeast of White Mound, 2½ miles southeast of Dougherty, where rain pyramids develop on the unindurated slopes of this shale beneath the thin disc-shaped associated barite crystals which protect the loose clay. A few feet of the basal beds are generally much more resistant, being calcareous and carbonaceous. In some localities, as at the south end of Scott's Dome, 7 miles southeast of Davis, there seems to be a gradation from the Fernvale limestone phase of the Viola through limestones and shaly limestones to the purer shale. At the top there is an abrupt change from the Sylvan shale into the oolitic basal member of the Chimneyhill limestone.

The thickness of the Sylvan shale (generally paced measurements) varies as follows: West Spring Creek, east of Pooleville, 324 feet; Henryhouse Creek, 353; U. S. Highway 77, 330; Cool Creek, 300; West Branch Sycamore Creek, 320; Middle of Criner Hills, 307; South end of Scott's Dome, 244; Murray Lane, south of Ada, 95; and a mile east of Atoka, 220 feet. The formation thins rapidly northward, where it is generally less than 50 feet in the subsurface of central and northern Oklahoma.

Miser and Purdue have described the Polk Creek as follows (2, p. 40):

> The shale is black, fissile and carbonaceous. In parts it is clayey, soft, and carbonaceous enough to soil the fingers in handling, but in others, especially the lower part, it is a hard siliceous slate. The thickness varies from 0 to 175 feet, but it is generally about 100 feet thick.

### AGE AND CORRELATION

The age is considered to represent upper Richmond, at the top of the Ordovician. Taff's earliest statement about the age of the Sylvan shale is as follows (3):

> Fossils have been found only in the green shales near the base of the formation in two localities, near the north-central part of the Arbuckle Mountains, and indicate lower rather than Upper Silurian age.

A year later he wrote as follows (4):

> The position in the stratigraphic column to which the Sylvan shale should be assigned may be questioned, but the faunal evidence doubtless is in favor of Ordovician age.

In spite of the evidence of the fauna,

because the upper part of the Viola had been considered uppermost Ordovician, he seemed forced to place the Sylvan in the Silurian, equivalent to the Medina of the east. However, it is now thought that the upper Fernvale phase of the Viola and the Sylvan shale each represents part of the Richmond. This view is strengthened by the fact that one of the most important graptolites in the base of the Sylvan shale, *Dicellograptus complanatus*, is an important horizon marker in the upper Hartfell shale near the top of the Ordovician in Great Britain (1). As the lower part of the Chimneyhill limestone is considered Clinton in age, the Medina seems to be represented in this region only by a hiatus.

For a time it was considered almost impossible to carry a definite correlation of formations across from the Arbuckle Mountains to the Ouachita Mountains to the east. Now the graptolites of the Sylvan shale are forming an important wedge to make a significant opening in this problem. Not only have the graptolites typical of the Sylvan shale been found east and northeast of Atoka, but over 200 feet of shale with many of the characteristics of the Sylvan is there, though slightly more indurated and more brownish in color. This evidence has been augmented also by finding not only several graptolite zones of the Viola limestone, but also one of its most characteristic trilobites, *Cryptolithus tessellatus*, in considerable numbers in that part of Taff's Talihina chert which forms the Black Knob Ridge northeast of Atoka and which is well exposed in the Stringtown quarry. This Talihina chert is thus taken to represent the eastward extension of a part of the Viola limestone of the Arbuckle Mountains of Oklahoma, and the westward extension of the Bigfork chert of Arkansas. East of Atoka this Viola phase of the Talihina chert seems to grade upward without any break into Sylvan shale above without the presence of the Fernvale phase characteristic of the top of the Viola in Arbuckle Mountains.

Furthermore, as nearly all graptolites of the Sylvan shale have been found in the Polk Creek shale of Arkansas, the practical equivalence of large parts of these formations seems to be established in so far as the graptolites of the Polk Creek shale have been studied.

Possibly with the old idea in mind that the Sylvan shale is equivalent to the Medina, Ulrich seemed to think that the Sylvan shale is much younger (2, p. 41) than the Polk Creek shale even though most of the graptolites of the Sylvan are found in the Polk Creek. Still, he recognized that three of the important graptolites of the Sylvan shale are found in the Polk Creek shale, and that *Dicellograptus complanatus*, found in both of them, is a significant horizon marker for the upper Hartfell shales of Great Britain. He explains the presence in the Polk Creek shale of *Glossograptus* (*Orthograptus*) *quadrimucronatus* as possibly coming from a lower siliceous shale zone which might be included in the top

of the Bigfork chert instead of the base of the Polk Creek shale.

Possibly one reason why the Polk Creek shale was placed in a lower horizon was because the varieties of *Glossograptus quadrimucronatus* and *Diplograptus calcaratus* found in it were not differentiated from the typical forms in the Utica shale of America and the lower Hartfell shale of Great Britain. The position taken here is that these species lived on to a later age in Arkansas, and there, in association with a younger fauna, became differentiated into the varieties *paucithecatus* and *tridentatus*. Accordingly, the Sylvan and Polk Creek shales are both placed at the top of the Ordovician with the lower boundary of the Silurian above them instead of at the base of the Sylvan. The reasons for differentiating these varieties are given in the descriptions below.

### PRESERVATION OF THE GRAPTOLITES

In many localities the graptolites are extremely abundant in the Sylvan shale, especially in the lower part, and in some places they range up to the middle of the formation. Yet, so often the shales are so loose and unconsolidated or so rough in appearance that it is almost impossible to collect complete rhabdosomes. Accordingly, it is necessary to search for outcrops in which the shales are better indurated and the texture finer and smoother. Locally, some good collections were made from recently exposed surfaces on which the graptolites are more resistant than the shale, so that they stand out in relief, and being black, they contrast strongly with the lighter bleached surface of the shale.

The Polk Creek shale is generally black, carbonaceous, fissile, and almost slaty. On the black surfaces of this formation, the altered lighter colored graptolites stand out in marked contrast on the dark shale. Locally, the metamorphism has been so great that the graptolites have been changed to gümbelite, a silvery substance which contrasts still more strongly with the black shale.

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EXPLANATION OF FIGURE 1

*a–e—Dicellograptus complanatus* Lapworth. *a*, Twisted fragments of one side of large colony, ×4, West Spring Creek, Arbuckle Mts. *b*, *c*, Side and obverse views proximal end of narrow rhabdosome, ×4, Muddy Boggy Creek, east of Atoka; northeast edge of Ouachita Mts. *d*, *e*, Side views, proximal end and distal fragment of broad rhabdosome, ×4, Henryhouse Creek, Arbuckle Mts. (p. 702)

*f–i—Diplograptus crassitestus* Ruedemann. *f*, Side view, ×4; *g*, obverse view, ×4, both Muddy Boggy Creek east of Atoka. *h*, Side view, ×4, Lawrence quarry, 7 miles south of Ada. *i*, Side view, ×4, northeast of Falls Creek; both *f* and *i* from Arbuckle Mts. (p. 702)

*j–l—Climacograptus mississippiensis* Ruedemann. *j*, Reverse view, ×4, West Spring Creek at west edge of Arbuckle Mts. *k*, *l*, Partly side, partly obverse view, ×1 and ×4; Muddy Boggy Creek east of Atoka, Ouachita Mts. (p. 704)

*m–o—Climacograptus putillus* (Hall). *m*, Side view of synrhabdosome, ×1, collected by Ruedemann on Cool Creek. *n*, *o*, Side views, ×4, both from south edge of Scott's Dome, and all three from Arbuckle Mts. (p. 706)

*p–t—Climacograptus tridentatus* (Lapworth) var. *maximus* Decker, n. var. *p*, *q*, Side view, ×4 and ×1 proximal end, spines broken off. *r*, Side view, ×1, distal fragment. *s*, *t*, Side view, ×1 and × 4, of proximal end with part of spines and impressions showing. All three specimens from Henryhouse Creek in Arbuckle Mts. (p. 707)

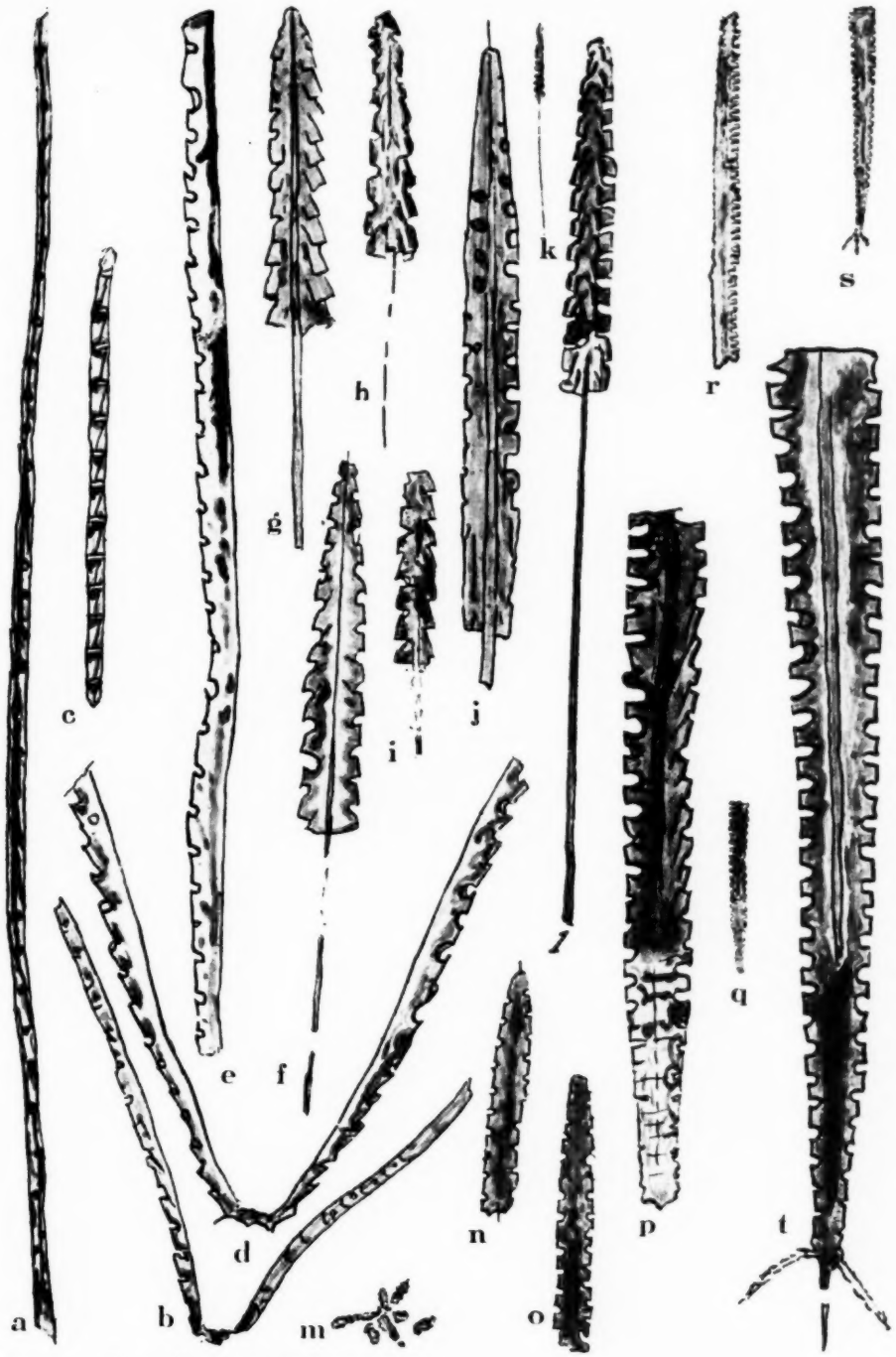


FIGURE 1.—Graptolites from the Sylvan shale.

## CHARACTER OF THE FAUNA

The group of graptolites from the Sylvan and Polk Creek beds is characterized by the complete absence of dendroid types, by the presence of only one form belonging to the Axonolipa, and by the fact that the majority of the virgula-bearing forms belong to the genus *Climacograptus*.

## SYSTEMATIC DESCRIPTIONS

### Order GRAPTOLOIDEA Lapworth

### Suborder AXONOLIPA Frech, emend Ruedemann

### Genus DICELLOGRAPTUS Hopkinson, 1871

#### DICELLOGRAPTUS COMPLANATUS Lapworth

Figure 1*a–e*, figure 2*g*

*Dicellograptus complanatus* LAPWORTH, *1880*, Annals Mag. Nat. Hist., vol. 5, p. 160, pl. 5, figs. 17*a–e*.—ELLES and WOOD, *1901–1918*, Monograph of British graptolites, p. 139, pl. 20, figs. 1a–*d*, text-figs. 84*a–c*.—RUEDEMANN, *1908*, New York State Mus., 61st Ann. Rept., vol. 3, appendix 4, Mem. 11, Graptolites of New York, pt. 2, p. 294, text-figs. 208, 209, pl. 18, fig. 1.

The two stipes of the colony usually diverge so as to include between them an angle of 40° to 60°, with a most commonly included angle of about 50°, though occasionally the stipes are bent more widely apart to include an angle of about 90°. The stipes are generally straight or slightly flexed, but in some forms the distal ends of the long stipes may be bent abruptly. In the larger colonies the stipes attain a length of 8 to 10 cm. or even more. Thecae 10 in 10 mm. in proximal region, decrease to 8 in the distal region, overlap about one-half their length. Width of stipe in proximal region, 0.5 mm., increasing rapidly distally to 1 mm., or a little more in flattened forms.

Thecae elongate, slender, with aperture horizontal though slightly introtorted in reentrants which occupy about one-third the width of the stipe. Sicula, broken from these specimens, is generally long and tapering. The thecae on either side of the sicula grow horizontally, then the next ones turn abruptly backward. Short spines extend from the apertures of the first two thecae on each side of the sicula.

*D. complanatus* occurs on the south side of the Arbuckle anticline in the Arbuckle Mountains of Oklahoma. Large colonies occur from the West Branch of Sycamore Creek to Henryhouse Creek, east of Woodford, to West Spring Creek near Pooleville. In these localities it occurs in the more indurated basal part of the Sylvan shale. On Muddy Boggy Creek, east of Atoka, it occurs in abundance farther up in the poorly indurated clay shales from which it is collected only with great difficulty. It occurs also in the black slaty Polk Creek shale of Arkansas in Heath valley a mile west of the Heath School. In the reference given in the synonymy above, Ruedemann referred two specimens from the Sylvan shale of Oklahoma with some doubt to *D. complanatus*. The finding of numerous good colonies of the species in the localities noted above confirms his reference of the forms to this species, and establishes the presence of this important British horizon marker in the Richmond of Oklahoma and Arkansas. In England it occurs definitely in the Upper Ordovician where it is the chief horizon marker of the upper Hartfell shales.

*Hypotypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2361–A2365 and A2376.

### Genus DIPLOGRAPTUS McCoy, 1854

#### DIPLOGRAPTUS CRASSITESTUS Ruedemann

Figure 1*f–i*, figure 2*h*

*Diplograptus crassitestus* RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 354, text-figs. 299, 300, pl. 25, fig. 6.

Though a synrhabdosome has not been found, numerous separate, beautifully symmetrical rhabdosomes may be seen. The form tapers gradually from the width of 0.5 mm. to 2 mm. in the distance of 9 or 10 thecae. It is characterized by a rather thick-set nemacaulus which may be seen the full length of the colony on its reverse side. Often the free end of the nemacaulus is nearly if not quite as long as the part set with thecae. Thecae 11 or 12 to 9 in 10 mm. when measured on a number of different specimens. Though Doctor Ruedemann credits his type form with 7 to 10 in 10 mm., this seems too small a number, for in the text-figure 299, noted above, ×5, the thecae measure 9 to 11½ in 10 mm. The width of thecae seems to depend something on the view, but they are generally about one-half as wide as long and overlap about one-half the length. The considerable variation in form shown in the five illustrations is doubtless due in part to difference in the position of the rhabdosomes. The angle of divergence is 30° to 40°. The thecae generally slope clearly in the true diplograptid fashion, but near the distal end of some forms there seems to be a close approach to the climacograptid habit. The forms found in the Sylvan shale in the Arbuckle Mountains, the west edge of the Ouachita Mountains, and in the Polk Creek shale of Arkansas are clearly the same species. The distribution of this species, earlier limited to the Sylvan shale of Oklahoma, is now extended to the Polk Creek shale of Arkansas.

*Hypotypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2366–A2369, and A2377.

DIPLOGRAPTUS CALCARATUS Lapworth
var. TRIFIDUS (Gurley)
Figure 2*n–p*

Cf. *Diplograptus foliaceous* var. *calcaratus* LAPWORTH, *1876*, Cat. West Scot. Foss., p. 6, pl. 1, fig. 30.

*Diplograptus trifidus* GURLEY, *1890*, Geol. Survey Arkansas, Ann. Rept., vol. 3, p. 417, pl. 9, figs. 3, 4; *1896*, Jour. Geol., vol. 4, pp. 298, 307.

*Diplograptus foliaceous trifidus* RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 351, text-figs. 294, 295.

Cf. *Diplograptus* (*Orthograptus*) *calcaratus* ELLES and WOOD, *1901–1918*, Monograph of British graptolites, p. 239, 3 text-figs., pl. 30, figs. 1*a–c*.

This very large variety of *Diplograptus* is characterized by its great length, 10 cm. or more, and great width up to 5 mm., and by its three prominent proximal spines, one central virgellar and two lateral apertural ones. A strong virgular tube is extended distally. The British species *D. calcaratus* is assigned a maximum width of 2.5 to 3.5 mm. with thecae 10 to 8 in 10 mm. Gurley's specimen is 1.5 mm. wider, or 5 mm., and the thecae of some of these later Arkansas forms are longer, measuring 10 to 7 in 10 mm., or one less than the normal earlier form in the mature part of the rhabdosome; collected from the Polk Creek shale a mile west of Heath School, Heath valley, sec. 15, T. 3 S., R. 29 W., Arkansas. Because this Arkansas variety is much enlarged in every dimension above the size of the typical British species, and because it occurs in association with a much younger fauna, it is given a varietal name *trifidus*, which Gurley used for the name of the species.

*Syntypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2382, A2383.

Genus GLOSSOGRAPTUS
Emmons, 1856

GLOSSOGRAPTUS QUADRIMUCRONATUS Hall
var. PAUCITHECATUS Decker, n. var.
Figure 2*i–k*

*Glossograptus* (*Orthograptus*) *quadrimucronatus* (HALL), *1865*, Canada Org. Rem., Dec. 2, p. 144, pl. 13, figs. 1–10.—RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 385.

In this last reference Ruedemann lists 29 synonyms with references for this species.

This species is large and occurs in synrhabdosomes. It is a large form, 6 cm. or more in length, and attains a width of

3 mm. The thecae frequently bear lateral spines, number 11 in 10 mm. This new larger variety *paucithecatus* attains a width of 4.5 mm. and has 10 to 7 thecae in 10 mm. The relatively large species *G. quadrimucronatus* has developed into several varieties which taken together have a wide distribution and a relatively long time range. The climax of the species is found in the Polk Creek shale at the top of the Ordovician at Brashear's place near Chalybeate Spring on Cedar Creek, 7 miles northwest of Buckville, Arkansas. At this locality some very large forms with large, long thecal spines occur. The widest specimen measures 4.5 mm., or 1.5 mm. above normal size, and the thecae are longer in the mature part, numbering only 7 in 10 mm. Because of the great width of the rhabdosomes and the great length of the thecae, it is given the new varietal name, *paucithecatus*.

*Syntypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2378, A2379.

Genus CLIMACOGRAPTUS Hall, 1865

CLIMACOGRAPTUS MISSISSIPPIENSIS Ruedemann

Figure 1*j–l*, figure 2*l*

*Climacograptus mississippiensis* RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 413, text-figs. 366, 367, pl. 28, figs. 12, 13.

Ruedemann's original description in above reference is as follows:

Synrhabdosomes not observed. Rhabdosomes small, maximum observed length 15 mm., length of majority of specimens 7 to 10 mm.; width at sicular extremity, 0.6 mm., increasing quite rapidly to maximum width of 2 mm. Sicular extremity furnished with rod like virgella (1.8 mm. long), but without lateral spines. Lateral faces flat or slightly concave, nearly smooth. Septal groove beginning at the sixth pair of thecae on obverse side and apparently absent on the opposite side. Sicula long and slender (1.8 mm.). Thecae numbering 12 in 10 mm. in the sicular part of the rhabdosome and 10 in the same space in the mature part (25–30 to the inch),

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EXPLANATION OF FIGURE 2

*a–d*—*Climacograptus tridentatus* (Lapworth) var. *maximus* Decker, n. var. *a*, Apertural view, ×1, proximal end of a rhabdosome. *b, c*, Side view, ×1 and ×4, proximal end, Muddy Boggy Creek, east of Atoka. *d*, Side view, ×4, proximal end of another specimen. (*a, d*, same locality as fig. 1*p–t*.) (p. 707)

*e*—*Climacograptus ulrichi* Ruedemann. Side view, ×4, proximal end, Cool Creek, Arbuckle Mts. (p. 707)

*f*—*Retiograptus* sp. Side view, ×4, of fragments of colonies showing typical mesh-like structure, Cool Creek, Arbuckle Mts. (p. 708)

*g*—*Dicellograptus complanatus* Lapworth. Side view, proximal end of colony, ×4. Sec. 26, T. 2 S., R. 2 W., Arkansas. (p. 702)

*h*—*Diplograptus crassitestus* Ruedemann. Side view of symmetrical rhabdosome, ×4. Delicate virgella proximally and long nemacaulus distally. Polk Creek shale, mile west of Heath School, Heath Valley, Arkansas. (Very like Sylvan form, fig. 1*f*.) (p. 702)

*i–k*—*Glossograptus quadrimucronatus* Hall var. *paucithecatus* Decker, n. var. *i*, Reverse view, ×1, proximal end of large colony showing lateral spines. *j, k*, Obverse view of part of another rhabdosome, ×4 and ×1. Polk Creek shale, Cedar Creek, 7 miles northwest of Buckville, Arkansas. (p. 703)

*l*—*Climacograptus mississippiensis* Ruedemann. Obverse view, ×4. Polk Creek shale, mile west of Heath School, Heath Valley, Arkansas. (p. 704)

*m*—*Climacograptus putillus* (Hall). Side view, ×4, Polk Creek shale, mile west of Heath School, Heath Valley, Arkansas. (p. 706)

*n–p*—*Diplograptus calcaratus* Lapworth var. *trifidus* (Gurley). *n, o*, Apertural view of large rhabdosome, ×1 and ×2; Polk Creek shale, mile west of Heath School, Heath Valley, Arkansas. *p*, Apertural view smaller rhabdosome, ×1. (Same horizon and locality as fig. 2*n, o*.) (p. 703)

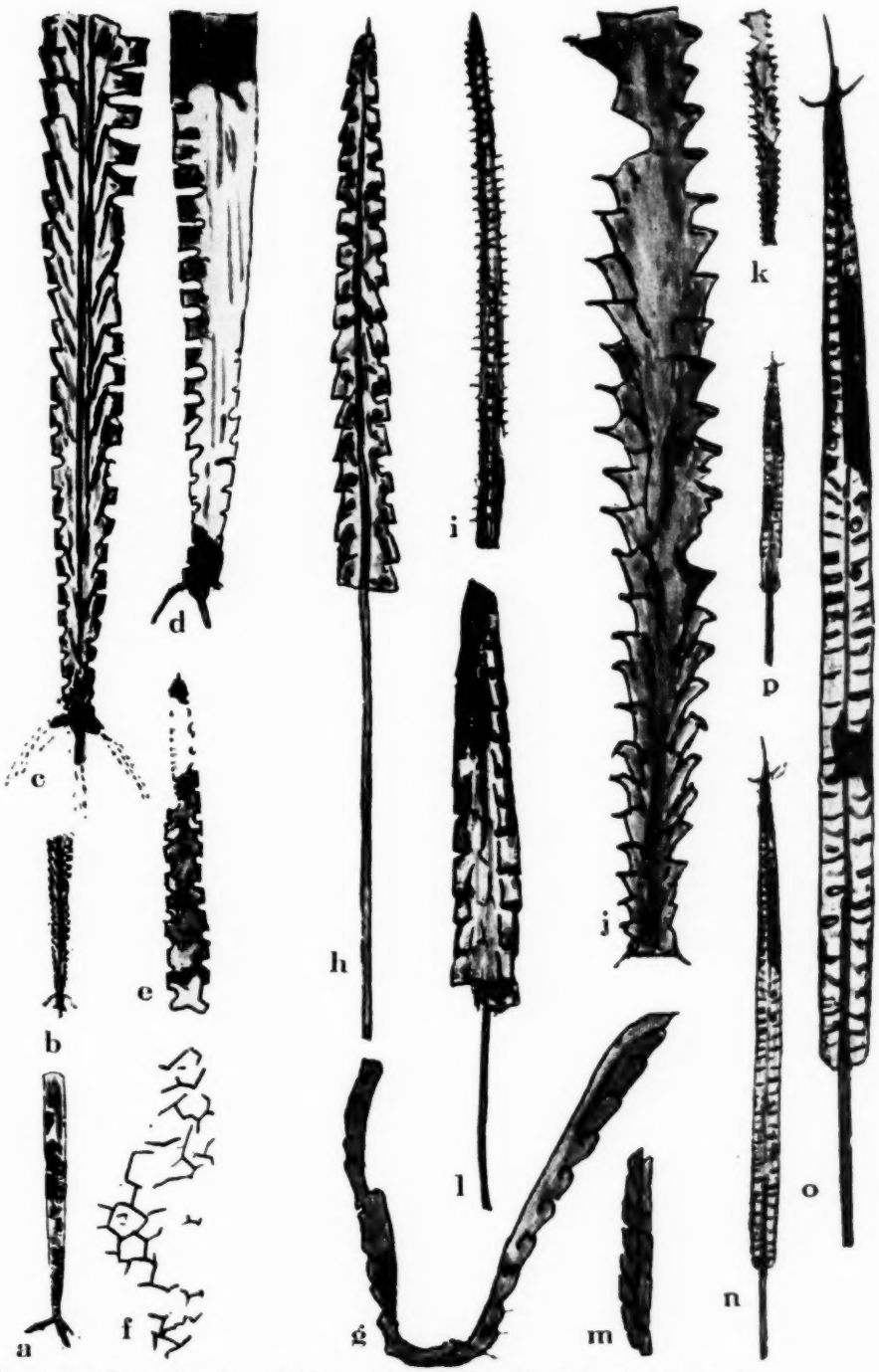


FIGURE 2.—Graptolites from the Sylvan shale (*a–f*) and Polk Creek shale (*g–p*).

of the form of those of *C. typicalis*. Apertures and apertural excavations also as in the latter species. Nemacaulus thin, rarely protruding and then but a short distance.

The specimens described were from the Sylvan shale of Oklahoma, and specimens collected later agree well with this description except that some of them are more than twice as long, due to the better preservation of the nemacaulus. Apparently the nemacaulus was broken from these earlier specimens, while in the specimen shown in figures 1*k*, *l*, it constitutes more than half of the entire length of the rhabdosome.

In the Sylvan shale this species has been found in the Arbuckle Mountains on West Spring Creek, on Henryhouse Creek, and at the south end of Scott's Dome, and in the edge of the Ouachita Mountains a mile east of Atoka, Oklahoma, on Muddy Boggy Creek. Also, it was found in the Polk Creek shale a mile west of the Heath School in Heath valley, Arkansas. It has been compared with *C. latus* from the same zone in England, but it is narrower than the latter form, and lacks the two lateral proximal spines which characterize the English species.

*Hypotypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2370, A2371, A2380.

CLIMACOGRAPTUS PUTILLUS (Hall)

Figure 1*m–o*, figure 2*m*

*Graptolithus putillus* HALL, *1865*, Geol. Survey Can., Org. Rem., pp. 27, 44, figs. 10–12*a*.
*Diplograptus putillus* HALL, *1868*, State Cab. Nat. Hist., 20th Ann. Rept., pp. 195, 211, pl. 2, figs. 10–12*a*.—NICHOLSON, *1868*, Geol. Soc. London, Quart. Jour., vol. 24, p. 527, pl. 19, figs. 17, 18.—TULLBERG, *1882*, Sver. Geol. Unders., ser. c, no. 50, p. 43.—WALCOTT, *1883*, Albany Inst., Trans., vol. 10 (Advance Sheets) 1879, p. 35.—LAPWORTH, *1886*, Roy. Soc. Canada, Proc. and Trans., vol. 4, pp. 170, 178 ff.—WALCOTT, *1890*, Geol. Soc., Bull., vol. 1, p. 339.—AMI, *1893*, Can. Rec. Sci. (1892–93), vol. 5, p. 224.—GURLEY, *1896*, Jour. Geol., vol. 4, p. 298.—WINCHELL and ULRICH, *1897*, Geol. Minnesota, vol. 3, pt. 2, p. 111.—RUEDEMANN, *1901*, New York State Mus., Bull. 42, p. 498 ff.—NICKLES, *1902*, Cincinnati Soc. Nat. Hist., Jour., vol. 20, p. 68.
*Graptolithus (Diplograptus) putillus* WINCHELL and SCHUCHERT, *1895*, Geol. Minnesota, vol. 3, pt. 1, p. 82, fig. 3.
*Diplograptus teretiusculus* Hishinger, *1896*, sp. var. *putillus* FRECH, ROEMER and FRECH, Lethaea Pal., vol. 1, p. 628.
*Climacograptus putillus* RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 415, text-figs. 368–370, pl. 28, figs. 14, 15.

A synrhabdosome was collected by Doctor Ruedemann on Cool Creek in Oklahoma and it is shown natural size in figure 1*m*. The rhabdosomes are characteristically very small, as shown in this figure and in those on Plate 28 of Ruedemann's last reference above. The best description of this species is given by Ruedemann in above reference from which we quote as follows.

Rhabdosome very small (9 mm., mostly less) and slender (1–1.3 mm. wide), elliptic in section, widening gradually, possessing a gently wavy median furrow on each lateral face. Sicula small (1.3 mm.) and very slender, provided with a short apertural spine; its slender virgella protruding from the rhabdosome. Thecae tubular, little inclined to the axis of the rhabdosome in the proximal half and subparallel to it in the distal free half; closely arranged (12–14 in the space of 10 mm. or 32 in 1 inch); apertures straight, at right angles to longer axes of thecae. Nemacaulus thin.

The small size of this species is shown also in figures 1*n*, *o* and in figure 2*m*, where they are four times natural size. The two similar specimens on figure 1 are pressed flat and show only an inkling of the median line which is so characteristic of the type specimen. This median line shows better in the specimen from the Polk Creek shale of Arkansas, in figure 2*m*. None of these figures show clearly the alternation of the thecae nor the swelling at the base of each theca shown in Hall's original illustration.

The type specimen came from Maquoketa Creek, Iowa, where it is doubtless from the Maquoketa shale, taken to be the approximate equivalent of the Sylvan shale of Oklahoma. The long range of

Utica to Richmond assigned to this species is doubtless due to the fact that several other small forms have been mistaken for it and have been classed with it. Since publication, Ruedemann in his text figures, has recognized that those from the Eden shale are *C. pygmaeus* and those from Rural Cemetery, New York are *C. strictus*. If all the specimens credited to this species could be carefully restudied, this form would doubtless come to its own importance as marking a limited horizon.

It occurs in great abundance in the lower part of the Sylvan shale of Oklahoma, and ranges up to about 100 feet above the base at some localities. Because of the identification of several other species with this form, neither the long geologic range, nor the wide geographic distribution assigned to it, can be considered as proven.

*Hypotypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2372, A2373 (from the Sylvan shale of Oklahoma), and A2381 (from the Polk Creek shale of Arkansas).

CLIMACOGRAPTUS TRIDENTATUS (Lapworth) var. MAXIMUS Decker, n. var.

Figure 1*p–t*, figure 2*a–d*

*Climacograptus bicornis* HALL, *1847*, Paleont New York, vol. 1, p. 268, pl. 73, fig. 2.

*Climacograptus bicornis* var. *tridentatus* LAPWORTH, *1876*, Cat. West. Scot. Foss., pl. 2, fig. 52; *1877*, Grap. Co. Down, p. 139, fig. 38*c*.—ELLES and WOOD, *1901–1918*, Monograph of British graptolites, p. 195, pl. 26, figs. 9*a–c*.

The variety *tridentatus* Lapworth, is included by Ruedemann in his list of over 35 synonyms for *C. bicornis* (*New York State Mus., Mem.* 11, Graptolites of New York, pt. 2, pp. 433–437, text-figs. 404, 405, pl. 28, figs. 24–28, 1908).

This very large variety has thecae typical of *C. bicornis*, and the three proximal spines which typify Lapworth's variety *tridentatus*. As this proximal three-spined type of *bicornis* remained so constant through several formations, *tridentatus* is raised to the position of a species, and the new varietal name of *maximus* is added to this greatly enlarged later form. No complete rhabdosome was collected, but measurements of fragments of the tapering proximal and mature distal regions, would increase the length above that of var. *tridentatus* by one-third, or possibly more, certainly to 8 cm., and possibly to 10 cm. Then the typical mature width of *bicornis* of 2.5 mm. is increased to 4 mm. in this variety. Also, the length of the thecae is increased to 11 to 9 in 10 mm. instead of 12 to 10 in 10 mm. typical of the older varieties. The proximal spine-like virgella is likewise increased from a length of 2 mm. to 3 mm.

Thus this very large form seems to have outdistanced all of its earlier forebears and relatives in every dimension to reach this climax of size in the top of the Ordovician.

This variety was found in abundance in the basal part of the Sylvan shale on Henryhouse Creek in the southwestern part of the Arbuckle Mountains, and some typical forms were found at the same horizon on Muddy Boggy Creek, a mile east of Atoka in the northwest edge of the Ouachita Mountains. Thus another strong link is added to the chain which is uniting the formations of these two regions in a manner considered impossible a short time ago.

*Syntypes.*—Mus. Inv. Paleont. Univ. Oklahoma, A2374, A2375, B2361, B2362, B2363, B2364.

CLIMACOGRAPTUS ULRICHI Ruedemann

Figure 2*e*

*Climacograptus ulrichi* RUEDEMANN, *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 412, text-figs. 364, 365, pl. 28, figs. 10, 11.

This is a very small form, the fragment having a length of a little over 1 cm. and width of 1.5 mm.

Ruedemann's original description is as follows:

Synrhabdosomes not observed. Rhabdosomes small (12–18 mm.). Sicular end as in *C. typicalis*, narrow and acutely pointed, furnished with short stout virgella and an

opposite parallel, sicular mucro; rhabdosome attaining its full width within 3 mm., its margins parallel thereafter. A free prolongation of the nemacaulus mostly present, attaining half the length of the rhabdosome. First one or two pairs of thecae narrow and appressed to nemacaulus, as in *C. typicalis*, later thecae bent twice; the middle part directed obliquely outward and the proximal and distal parts subparallel to axis of rhabdosome. Aperture normal to distal part of the theca, interthecal excavation long but shallow. Thecae numbering 12 to 10 in 10 mm.

The form illustrated was collected from the Sylvan shale on Cool Creek, south edge of the Arbuckle Mountains of Oklahoma. The original type of the species described above came from the Maquoketa shale at Spencer, Missouri. In this connection, it is interesting to note that the two species *C. putillus* and *C. ulrichi* both occur in the lower part of the Sylvan, in the Maquoketa shale, and in the Polk Creek shale of Arkansas (2, p. 41). *C. putillus* is illustrated in figures 1*m–o* and figure 2*m* of this paper.

*Hypotype.*—Mus. Inv. Paleont. Univ. Oklahoma, B2365.

Genus RETIOGRAPTUS Hall, 1865

RETIOGRAPTUS sp.

Figure 2*f*

*Retiograptus* HALL, *1865*, Graptolites of the Quebec group, Geol. Survey Canada, dec. 2, p. 115.—RUEDEMANN, *1905*, New York State Mus., Mem. 7, Graptolites of New York, pt. 1, p. 732; *1908*, New York State Mus., Mem. 11, Graptolites of New York, pt. 2, p. 462.—ELLES and WOOD, *1901–1918*, Monograph of British graptolites, p. 315.

*Clathrograptus* LAPWORTH, *1873*, Geol. Mag., vol. 10, p. 559.

The specimens of *Retiograptus* are too fragmentary to determine a species or variety, but the forms clearly belong to the genus *Retiograptus*, so it is included here. Its chief interest lies in the fact that the genus, which is commonly Middle Ordovician or a little higher, is here found associated with *Diplograptus crassitestus* in the Sylvan shale from Cool Creek, Oklahoma, where it is in the topmost formation of the Ordovician.

*Figured specimen.*—Mus. Inv. Paleont. Univ. Oklahoma, B2366.

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# A DEVONIAN FAUNA FROM THE SACRAMENTO MOUNTAINS NEAR ALAMOGORDO, NEW MEXICO

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ABSTRACT

The occurrence of fossiliferous Devonian strata in the Sacramento Mountains east of Alamogordo, New Mexico, is described and the fauna listed and illustrated. Correlations based on recognizable species show close relationship to the Independence shale of Iowa rather than to the nearer Percha shale. The bearing of this on the origin of the faunas of the Iowa basin is discussed and support is drawn for invasion of that region from the southwest.

Strata occurring in the Sacramento Mountains and said to carry fragmentary fossils of probable Devonian age were described and mapped by Darton (1, p. 211). The beds lie immediately above the Fusselman limestone and below rocks of Mississippian age. They outcrop continuously along the west front of the mountains from Alamogordo southward nearly to Grapevine Canyon, a distance of some 20 miles. This outcrop is one of the easternmost of Devonian age in the Rocky Mountain region and might be expected to carry fossils, if any, related to those in the western part of the upper Mississippi Valley. During the examination of the rocks in these New Mexico mountains, with this possibility in mind, the fauna discussed below was discovered.

Southeast of Alamogordo, the westward flowing Alamo Creek has cut a deep canyon in the west front of the Sacramento range. This canyon cuts across the strike of the rocks forming the mountains and reveals in its bold walls a succession of Paleozoic strata ranging from the Cambrian to the Pennsylvanian. The various beds are well exposed for the most part but the Devonian shales and limestones are less resistant and outcrops are usually covered with soil and talus or overgrown with vegetation. Consequently good exposures affording fossil collecting are few. The one discovered is situated in the east end of the Gordon Canyon branch of the main canyon some 4 or 5 miles above the mouth of the latter. Here a dry ravine enters the main creek from the east with such gradient that during the rainy season the waters sweep the rocks clean. In this ravine a section of Devonian, Mississippian, and Silurian strata is available in a distance of 10 rods.

The Devonian rocks are visible only in a small area about 20 feet wide by 40 feet long. Yet nearly the whole section of the Devonian is exposed, as the strata dip steeply eastward at an angle of more than 45° and the ravine extends across their strike. Lithologically the major portion of the beds consists of grayish-

buff calcareous shales, rather non-resistant and weathering to earthy, non-sticky material. Interbedded with the shales are thin, harder, irregular layers of argillaceous buff limestone several inches in thickness. The shale carries few, if any, large fossils, most of these being obtained from the limy layers. At the top is a bed of dense black carbonaceous shale, seemingly devoid of macrofossils and weathering into chippy pieces. It grades above into a thin layer of gray shale, softer, more earthy and carrying numerous poorly preserved fossils.

The section of Devonian and adjacent strata observable in this ravine is as follows:

*Section in Alamo Creek Southeast of Alamogordo*

| | Thickness Feet |
|---|---|
| MISSISSIPPIAN | |
| 12. Limestone, massively bedded, dense, bluish on broken surfaces, crinoidal, containing some chert and calcite seams. A 2-foot layer, completely disintegrated into crinoidal fragments, resembles typical Burlington. Total thickness approximately | 30 |
| 11. Shale, calcareous, with layers of limestone nodules, the nodules being hard and resistant and somewhat flattened. Fossils quite numerous in the upper portion, especially crinoidal segments, *Cliothyridina*, *Zaphrentis*, and Bryozoa | 20 |
| 10. Limestone, dense, bluish on fresh exposures, massively bedded, fossiliferous, crinoidal | 8 |
| 9. Shale, gray, calcareous, not resistant, containing numerous irregular, more or less discontinuous layers of limy nodules which are hard and tough, with dimensions up to 2 and 3 inches | 30–40 |
| 8. Limestone, dense blue-gray, hard resistant, nodular, irregularly bedded, with numerous small fossils | 10 |
| 7. Shale, gray, with numerous irregular layers of calcareous nodules; fossiliferous, *Spirifer* and other shells being noted. A 3- or 4-inch layer of limestone, slightly irregular along the contact, directly overlies the shale below | 4 |

[In these strata fossils are numerous, but good recognizable examples are uncommon. Several brachiopods are at hand which are well preserved and have been provisionally identified as *Spirifer latior* Swallow, *Cliothyridina glenparkensis* Weller, *Schizophoria choteauensis* Weller, and *Composita* cf. *C.? corpulenta* Winchell. They are indicative of the Fern Glen division of the Mississippian and suggest that the nodular lower member of the Lake Valley limestone belongs to this system rather than the Devonian (1, p. 17).]

| | |
|---|---|
| DEVONIAN | |
| 6. Shale, dark, dense, massively bedded but tending to weather into chippy pieces. This resembles typical Percha shale as seen at Kingston, New Mexico. It lies directly on a bed of limestone, the contact being visible, in apparent conformity but the lowermost 3 or 4 inches of the shale is yellowish and calcareous. The shale has pyrite in spherical nodules and is for the most part unfossiliferous. The uppermost 10 inches is brownish in color and less resistant, but is highly fossiliferous at base, *Chonetes*, *Ambocoelia*, *Lingula*, *Crania* and *Liorhynchus* being noted. Three inches from the top is a somewhat nodular layer | 4 |
| 5. Shale, buff to yellow, calcareous, non-resistant, earthy and containing occasional intercalated layers of limestone, 2 to 6 inches thick, harder and more resistant and usually fossiliferous. The shale is very calcareous and grades into the limestone layers which are thicker toward the top | 10 |
| 4. Shale, yellowish to buff, non-resistant, earthy, grayish in places, soft, and more or less covered | 10 |
| 3. Covered, apparently shale, questionably Devonian | 5–6 |
| SILURIAN | |
| 2. Limestone and shale, the topmost 8 feet are limestone, hard, tough, resistant, rather mas- | |

sively bedded, bluish in color on fresh surface, very nodular, grading at the bottom into beds below. The lowermost strata are shaly, calcareous, thinly bedded, with irregular seams of harder limestone or chert..... 14

1. Limestone, heavily bedded, bluish-gray, hard, tough, resistant, appearing to have an argillaceous content, carrying a few fossils difficult of extraction; bryozoans, brachiopods of Silurian appearance..... 50

The Devonian fauna collected at this small exposure is an interesting and varied one and comprises some thirty species. Of these the brachiopods are by far the most numerous specifically and most valuable for correlation. The corals, though not as numerous, are distinctive and easily recognized. Other phyla are represented by several species but are less useful because of poor preservation or lack of distinctive characteristics. The complete list of the forms occurring in the buff limy member as now determined, although further study may change some identifications, is as follows:

*Devonian Fossils from Alamo Creek Exposures (Bed 5)*

CORALS

*Macgeea parva* Webster
*Aulopora* cf. *expansa* Fenton and Fenton
*Microcyclus?* sp.

BRYOZOANS

A fenestelloid form
A massive species

BRACHIOPODS

*Dalmanella infera* (Calvin)
*Douvillinella variabilis* (Calvin)
*Douvillina arcuata* (Hall)
*Stropheodonta calvini* Miller
*Productella walcotti* Fenton and Fenton
*Leptostrophia* sp.
*Pugnoides subacuminata* Webster
*Atrypa* sp.
*Atrypa devoniana* Webster
*Atrypa rockfordensis* Fenton and Fenton
*Ambothyris?*
*Cyrtina iowaensis* Fenton and Fenton
*Spirifer* cf. *orestes* Hall
*Cranaena* sp.

ECHINODERMS

Abundant segments of crinoid stems

MOLLUSKS

*Tentaculites* sp.
*Orthoceras* sp.

OSTRACODES

Several undescribed forms resembling *Bairdia* and *Bythocypris*

FISHES

*Ptyctodus calceolus* Meek and Worthen

The fossils from the 1-foot layer of gray shale at the top of the black shale member (Bed 6) are less well preserved and have been generically determined only. They are: *Lingula* sp., *Ambocoelia* sp., *Chonetes* sp., *Liorhynchus* sp., and several undetermined forms of ostracodes.

The fossiliferous argillaceous strata of Devonian age outcropping in the Sacramento Mountains and bearing the fauna listed above, have been called the Percha shale (1, p. 201). Examination of a representative Percha fauna personally collected from the type area near Hillsboro, New Mexico, reveals that there is no relationship between the two faunal assemblages. In the dominant group, the brachiopods, there is not a single species in common and the generic aspect is very different. The corals are entirely distinct as are the bryozoans and mollusks. The dissimilarity is nearly complete and seemingly precludes correlation of the Alamo Canyon beds with the Percha shale.

A fauna of nearer occurrence also shows similar discrepancies. Along the east front of the San Andreas Mountains is an extensive linear outcrop of fossiliferous Devonian shale

correlated by Darton with the Percha shale (1, p. 187). A small collection was made from these beds at an exposure some forty miles northeast of the Alamo Canyon area or almost halfway to the Hillsboro region. Study of this fauna shows that there are four or five species that are typical Percha shale forms and others which are not. Of the species only one resembles any found in Alamo Canyon. This is a *Dalmanella* which resembles *Dalmanella infera* (Calvin) but differs in possessing slightly larger costae and a thinner shell. However, faunal lists of other collections made at several points along the San Andreas uplift and not seen by the writer indicate that the relationship may be closer than shown by the material at hand (1, p. 187).

Surprisingly, a fauna which is nearly identical with that of the Alamo Canyon beds is found more than a thousand miles northeastward in the east-central portion of the state of Iowa, near Brandon. There a blue shale, discontinuous in distribution and found in only a few scattered localities, lies below the Cedar Valley limestone. This shale was described by Calvin and named the Independence shale after the town near which the original outcrop was found. Its fauna has much in common with that of the Cerro Gordo beds of the Lime Creek stage and some have correlated it with that formation (3). However, the Independence shale lies stratigraphically nearly 300 feet below the Lime Creek beds and also shows a number of distinct faunal differences. It carries a faunal assemblage of more

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EXPLANATION OF PLATE 83

FIGS. 1, 2—*Atrypa devoniana* Webster, brachial views, nat. size. 1, From Alamo Canyon; 2, from Independence shale at Brandon, Iowa.

3, 4—*Atrypa*, n. sp., brachial views, nat. size. 3, From Alamo Canyon; 4, from Indedependence shale near Brandon, Iowa.

5, 12, 13—*Pugnoides subacuminata* Webster. 5, From Alamo Canyon, nat. size; 12, front view, ×2, of specimen from the Independence shale, Amana, Iowa; 13, front view, ×2, of a specimen from Alamo Canyon.

6—*Atrypa rockfordensis* Webster, ×5, Alamo Canyon.

7—*Microcyclus?* sp., ×2, Alamo Canyon.

8, 25–28—*Macgeea parva* Webster. 8, Lateral view of a small specimen, ×2, from Alamo Canyon. 25, 28, Lateral and calicinal views, ×2, of a specimen from the Independence shale of Iowa. 26–27, Lateral and calicinal views of a specimen, ×2, Alamo Canyon.

9—*Douvillinella variabilis* (Calvin), ×2, Alamo Canyon.

10—*Aulopora* cf. *expansa* Fenton and Fenton, ×2, Alamo Canyon.

11—*Stropheodonta calvini* Miller, pedicle view, ×5, Alamo Canyon.

14—*Orthoceras* sp., nat. size, Alamo Canyon.

15—*Leptostrophia* sp., pedicle view, nat. size., Alamo Canyon.

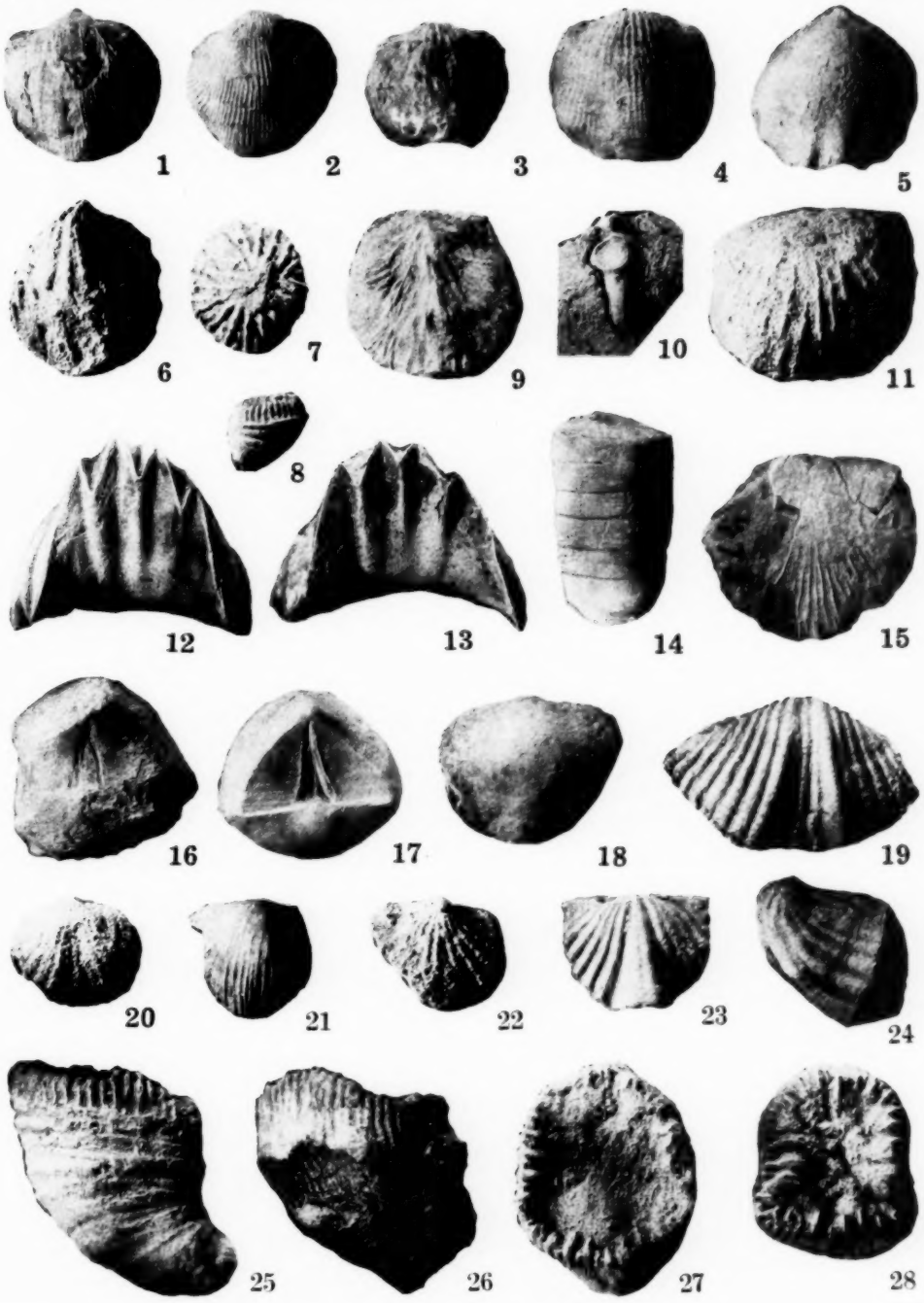
16–18—*Ambothyris?* sp. 16, Posterior view, ×2, of a specimen from Alamo Canyon. 17, Posterior view of a specimen, ×2, from the Independence shale, Brandon, Iowa. 18, Brachial view, ×2, of a specimen from Alamo Canyon.

19—*Spirifer* cf. *orestes* Hall, pedicle view, ×2, Alamo Canyon.

20, 22—*Dalmanella infera* (Calvin). 20, Brachial view of a specimen; 22, pedicle view of a specimen, both ×5, Alamo Canyon.

21—*Douvillina arcuata* (Hall), pedicle view, ×2, of a specimen from Alamo Canyon. This is the Independence variety.

23, 24—*Cyrtina iowaensis* Fenton and Fenton, brachial and lateral views, two specimens, ×2, Alamo Canyon.

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than 70 species, dominated in numbers by the brachiopods, which make up nearly half of the total, and closely followed in importance by the corals and echinoderms. Every one of the brachiopods found in the Alamo Canyon beds occurs in the Independence shale and of these five, namely, *Douvillinella variabilis*, *Leptostrophia* sp. *Ambothyris?*, *Atrypa* sp. and *Dalmanella infera*, are not found elsewhere. Seven of the brachiopods are also listed as members of the Lime Creek fauna but are varietally different in most cases and readily recognizable as Independence types. The *Douvillina arcuata* is small, coarse-ribbed and slightly keeled along the mid-line, thus differing widely from the larger Lime Creek form. The *Pugnoides* are robust ponderous individuals in comparison to those of the Lime Creek but identical with Independence forms. The *Atrypa devoniana* and *Stropheodonta calvini* have typically Independence aspects. Of the corals, *Macgeea parva*, originally described from the Independence shale, hitherto has only been found therein and further emphasizes the dissimilarity of the Alamo Canyon fauna with that of the Lime Creek. The other forms, bryozoans, mollusks, and ostracodes, are similar to those of the Independence but further study will be necessary to determine their equivalence. The Alamo Canyon fauna is then very near that of the Independence shale of Iowa, and these beds are correlated with that formation.

The fauna of the upper black shale in the Alamo Canyon differs also from that of the beds immediately below in nature and in preservation. The bottom conditions, as indicated by the lithology, were probably very different. With the possible exception of the ostracodes the species are not like those below but do not, as far as now determined, indicate any relationship with the typical Percha shale fauna. On the other hand the *Lingula* and *Chonetes* resemble forms from the Independence shale.

Several problems are raised by the relationships shown by this faunal study. Do the Alamo Canyon strata belong to the Percha shale? The faunal evidence seems to be against this conclusion. However, there are several possibilities. The Alamo Canyon beds may be the lower part of the Percha. At Hillsboro the major portion of the Percha formation is a black shale with thinner buff limy fossiliferous layers at the top. At Alamogordo the fossil-bearing limy beds are at the bottom with the black shale above. The shales carrying Devonian faunas found at various places in the Franklin Mountains, the Sacramento Mountains, the San Andreas Mountains and the Sierra Caballos, generally correlated with the Percha shale, may be parts of that formation but with varying stratigraphic positions or facies. It is possible that these strata may be different formations representing several marine invasions from several directions. Definite conclusions demand further study of these beds and their faunas.

The Alamo Canyon beds on the other hand are confidently correlated

with the Independence shale of Iowa and may thus throw considerable light on the origin of this fauna previously only known from the Upper Mississippi Valley. Schuchert has correlated beds of the Iowa Devonian with those of western Canada, particularly those of the Lake Manitoba and the Mackenzie Valley, and has shown in his paleogeographic maps an invading sea advancing southeastward into Iowa, Missouri and adjacent states. This solution has sometimes puzzled workers in the Mississippi Valley region, as the faunas of the Iowa formations especially do not seem to correspond closely with those of the Mackenzie embayment. For instance, *Stringocephalus burtini*, characteristic member of the fauna brought in by this invading sea from the northwest, has as yet not been recovered from Iowa. Nor have typical Independence shale or Lime Creek forms been reported from the northwest Canadian localities. Faunas similar in many respects to those of the Mississippi Valley Upper Devonian strata have long been known in New Mexico, Arizona and Nevada. Stauffer has shown the possibility that the Upper Mississippi region was invaded by a sea from the southwest (2). The facts advanced in this paper support this conclusion. The water connection or path of invasion may have been to the northward of New Mexico and then eastward but this possibility is not suggested by evidence known to the writer. Invasion of the Iowa region from the northwest by way of the Mackenzie area is not precluded and probably did take place, as some species common to the two localities show. But incursions or recurrent migrations of faunas from the southwest are more strongly indicated by the faunal similarities, and the faunal succession in the Upper Mississippi Valley is explained more plausibly by this assumption.

During the latter part of the Paleozoic era there seems to have been a geosyncline or at least a negative area extending southwestward from Iowa to Texas as shown by the deposition of great thicknesses of Mississippian and Pennsylvanian strata there. Possibly the development of this structural feature was foreshadowed during the late Devonian by gentle depression which allowed the seas to advance from New Mexico to Missouri and Iowa. It is suggested that isolated or thin areas of Devonian shale or limestone may be present beneath the Mississippian beds of the Mid-Continent region. Study of well samples from this horizon would be of great interest as the presence of distinctive ostracodes in the Devonian beds of Iowa and New Mexico offers possibilities of easy recognition and assured correlation.

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# BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1933

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The following bibliography records the titles of 398 publications dealing either exclusively or only partly with foraminifera. Of this total, 356 papers were published during the year 1933, whereas 29 titles are added for the year 1932, and 17 augment the list already published for the year 1931 (*Jour. Paleontology*, vol. 8, pp. 238–244, 356–372).

I am indebted to Dr. M. L. Thompson for the list of new forms given in the paper by Lee (No. 216 of the following list).

During the year 1933 the writer recorded from the literature of foraminifera 3 new families, 23 new subfamilies, 45 new genera, 253 new species, 38 new varieties and 86 forms of foraminifera, to which the nomenclatura aperta has been applied. The following homonyms have been noted:

**Bonairea** nov. gen. Pijpers, preoccupied by H. Burington Baker, 1924, later changed by the author into *Ruttenia*.

**Cristellaria kochi** Pijpers, preoccupied by Reuss, 1865.

**Massilina jacksonensis** Cushman, preoccupied by Cushman, 1927.

**Camerininae** nov. subfam. Galloway has been used by Cushman since 1928.

**Silicininae** nov. subfam. (Fam. Lituolidae) was erected by Earland (**110,** 89) and published in June, 1933, to include the genera **Miliammina** Heron-Allen and Earland, **Silicosigmoilina** Cushman and Church and **Rzehakina** Cushman. In August, 1933, Cushman created his new subfamily Silicininae (Fam. Silicinidae Cushman) in which he places the genera **Silicina** Bornemann, **Involutina** Terquem and **Problematina** Bornemann, whereas the three mentioned genera of Earland's subfamily Silicininae are placed by Cushman into his new subfam. Rzehakininae (**74,** 144). As Earland's subfamily deserves priority, the writer proposes a new name, INVOLUTININAE nov. subfam., for Silicininae Cushman, 1933, non Earland, 1933.

**Tetrataxinae** nov. subfam. Cushman (**74,** 170) preoccupied by Galloway (**141,** 161).

Regarding the nomenclature of foraminifera the following remarks must be made: According to the recommendations of Article 20 of the *International Rules of Zoological Nomenclature*, specific denominations, such as **"subgoodlandensis," "subbadenensis"** and **"subbolcensis,"** should be avoided. *Conicospirillina trochoidea* Cushman is misnamed, as it may cause confusion with *Conicospirillina trochoides* (Berthelin, 1879, *Spirillina*, see *Cushman Lab. Foram. Res., Contr.*, vol. 2, 1927, p. 74, pl. 16, fig. 2). It may, furthermore, be mentioned that the gender of the genera **Ammobaculites, Discorbis, Eponides, Spiroplectoides** etc. is masculine and that the wrongly formed genus **Loxostoma** should be replaced by the correctly erected **Loxostomum.**

In many instances, by establishing new species the authors unfortunately do not give any hint as to the nearest related and already known species. In describing new species it would always be of great help to the workers in foraminifera, if such features as relationships and differences of the new forms with already known ones would be given. The same remark applies to such species which are designated under the rule of the nomenclatura aperta.

Two *nomina nuda*, **Cycloclypeus biplicatus** and **Miogypsina bantamensis** Tan in Koolhoven (**202**) are not listed below, as is also the case with **Calpionella carpathica** Murgeanu and Filipescu. The writer has suggested (see abstract No. 357, *Palaeontologisches Zentralblatt*, vol. 5, 1934/35) that the genus **Calpionella** should be removed from the foraminifera and be classed within the family of the **Tintinnidae** (Ciliata). Colom Casasnovas, independently, arrived at the same conclusion (see *Soc. Española Hist. Nat., Bol.*, vol. 34, 1934, pp. 379–388).

The genus **Nannoconus** Kamptner, 1931, listed below, in the writer's opinion most probably represents what has been called by de Lapparent (1925) **"embryons de Lagena."** Thus **Nannoconus steinmanni** Kamptner becomes a synonym of **Lagena colomi** de Lapparent, 1931.

**Frondicularia rehamnae** Russo (**304**) has already been published, in accordance with

the *International Rules of Zoological Nomenclature* (see *Jour. Paleontology*, vol. 8, p. 378, 1934). Through decision of the International Commission for Zoological Nomenclature in Budapest in 1927, however, a new species has explicitly only once to be published as a new form by the author.

**Spiroloculina robusta** Brady, 1884, has been designated as the genotype of the genus **Flintia.** The new variety **S. robusta** Brady var. **flinti** of Lipparini has, therefore, to be called **Flintia robusta** (Brady) var. **flinti** Lipparini.

The numbers in bold face type following the author's name in the Index refer to the publications of the preceding bibliography.

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## II. INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1933

**Acervulininae** nov. subfam., Galloway, **141,** 308. Cretaceous to Recent. Subfam. of Acervulinidae Schultze, 1854.

**Alveolinellinae** nov. subfam., Galloway, **141,** 148. Cretaceous to Recent. Subfam. of Alveolinellidae Cushman, 1928.

*Ammobaculites alexanderi* Cushman, **70,** 51, pl. 5, fig. 5. Upper Cretaceous, Texas.

——— *arenata* Cushman, **70,** 50, pl. 5, fig. 4. Upper Cretaceous, Arkansas.

——— *bargmanni* Earland, **110,** 80, pl. 2, figs. 23–26. Recent, Antarctic, South Georgia.

——— *expansus* Plummer, **281,** 65, pl. 5, figs. 4–6. Upper Midway, Eocene, Texas.

——— *midwayensis* Plummer, **281,** 63, pl. 5, figs. 7–11. Upper Midway, Eocene, Texas.

——— *stephensoni* Cushman, **70,** 49, pl. 5, fig. 2. Upper Cretaceous, Texas.

——— *subgoodlandensis* Vanderpool, **363,** 407, pl. 49, figs. 1–3. Lower Cretaceous, Oklahoma.

——— *texana* Cushman, **70,** 50, pl. 5, fig. 3. Upper Cretaceous, Texas.

*Ammodiscus?* sp. Wickenden, **385,** 157, pl. 1, fig. 1. Jurassic, Canada.

**Ammomassilina** nov. gen., Cushman, **68,** 32. Fam. Miliolidae. Genoholotype: *Massilina alveoliniformis* Millett, 1898. Recent, Malay Archipelago.

**Ammospirata** nov. gen., Cushman, **68,** 32. Fam. Textulariidae, subfam. Spiroplectamminidae. Genoholotype: *Pavonina mexicana* Cushman, 1926. Lower Oligocene, Mexico.

**Amphitreminae** nov. subfam., Galloway, **141,** 45. Subfam. of Lagenidae Schultze, 1854. Recent, Fresh-water.

*Angulogerina macgillavryi* Pijpers, **278,** 67, text figs. 82–86. Upper Eocene, Bonaire.

——— *molengraaffi* Pijpers, **278,** 67, text figs. 80, 81. Upper Eocene, Bonaire.

——— *ocalana* Cushman, **66,** 14, pl. 1, fig. 30. Upper Eocene, Georgia.

**Angulogerininae** nov. subfam., Galloway, **141,** 377. Subfam. of Uvigerinidae Galloway and Wissler, 1927. Jurassic to Recent.

*Anomalina subbadenensis* Pijpers, **278,** 72, text figs. 116–120 Upper Eocene, Bonaire.

*Archaias* sp. Gravell, **149,** 18, pl. 2, fig. 1. Middle Oligocene, Venezuela.

*Articulina terquemi* Cushman, **66,** 3, pl. 1, fig. 7. Upper Eocene, Mississippi.
*Astacolus* n. sp. aff. *Cristellaria crepidula* Brady, 1884 (non Fichtel and Moll, 1798) Thalmann, **345,** 252. Recent, Azores.
*Astacolus*, see *Cristellaria*.
*Asterocyclina*, see *Discocyclina*.
*Astrorhiza triangularis* Earland, **110,** 52, pl. 1, figs. 8, 9. Recent, Antarctic, South Georgia.
**Ataxophragmiinae** nov. subfam., Galloway, **141,** 211. Subfam. of Ataxophragmiidae Schwager, 1877. Jurassic to Recent.

*Baggina thalmanni* Pijpers, **278,** 69, text figs. 97–99. Upper Eocene, Bonaire.
*Bathysiphon alexanderi* Cushman, **70,** 49, pl. 5, fig. 1. Upper Cretaceous, Texas.
**Beedeina** nov. gen., Galloway, **141,** 401, pl. 36, figs. 17, 18. Fam. Fusulinidae. Genotype: *Fusulinella girtyi* Dunbar and Condra, 1927. Middle Pennsylvanian.
*Bigenerina minutissima* Earland, **110,** 98, pl. 3, figs. 36–38. Recent, Antarctic, South Georgia.
*Biloculina depressa* d'Orbigny, 1826, var. *bononiensis* Lipparini, 1932, **222,** 58, pl. 4, fig. 1. Upper Miocene, Italy.
*Bolivina advena* Cushman, 1925, var *elongata* Pijpers, **278,** 67, text figs. 87, 88. Upper Eocene, Bonaire.
——— *capitata* Cushman, **73,** 80, pl. 8, fig. 12. Recent, Tropical Pacific.
——— *distincta* Galloway, **141,** 352, pl. 32, fig. 9. [For *B. plicata* d'Orbigny, 1839, *Voy. Amér. Mérid.*, p. 61, pl. 8, figs. 5–7; non fig. 4.] Recent, Chile.
——— *globulosa* Cushman, **73,** 80, pl. 8, fig. 9. Recent, Tropical Pacific.
——— *mariini* Pijpers, **278,** 68, text figs. 89–92. Upper Eocene, Bonaire.
——— n. sp. aff. *Bolivina textularioides* Brady, 1884 (non Reuss, 1862), Thalmann, **345,** 252. Recent, Fiji.
——— *oceanica* Cushman, **73,** 81, pl. 8, fig. 10. Recent, Tropical Pacific.
——— *pseudopygmaea* Cushman, **73,** 79, pl. 8, fig. 8. Recent, Tropical Pacific.
——— *vadescens* Cushman, **73,** 81, pl. 8, fig. 11. Recent, Tropical Pacific.
*Bolivinita selmensis* Cushman, **70,** 58, pl. 7, figs. 3, 4. Upper Cretaceous Tennessee.
——— *subangularis* (Brady, 1881), var. *lineata* Cushman, **73,** 77, pl. 8, figs. 1, 2. Recent, Tropical Pacific.
**Bonairea** nov. gen., Pijpers, **278,** 72. Fam. Anomalinidae. Genotype: *B. coronaeformis* Pijpers, 1933. Upper Eocene, Bonaire. [Note: This new name, being already preoccupied by H. Burington Baker in 1924 for a subgenus of the gastropods, has been rejected by the author himself, see *Ruttenia* ut infra.]
——— *coronaeformis* Pijpers, **278,** 72, text figs. 121–129. Upper Eocene, Bonaire. [This species becomes now *Ruttenia coronaeformis* (Pijpers, 1933), see below.]
*Bulimina cooperensis* Cushman, **66,** 12, pl. 1, fig. 32. Upper Eocene, South Carolina.
——— *fijiensis* Cushman, **73,** 79, pl. 8, fig. 7. Recent, Tropical Pacific.
*Buliminella milletti* Cushman, **73,** 78, pl. 8, figs. 5, 6. Recent, Tropical Pacific.

*Camerina* sp. *a.* Gravell, **149,** 15, pl. 1, figs. 1–5. Oligocene, Venezuela.
**Camerininae** nov. subfam., Galloway, **141,** 414. Subfam. of Camerinidae Meek and Hayden, 1865. Jurassic to Recent; maximum development in Lower Tertiary. [Preoccupied by Cushman, 1929, *Cushman Lab. Foram. Research, Spec. Pub.* No. 1, p. 209.]
*Carpenteria* sp. Gravell, **149,** 21, pl. 2, figs. 6, 7. Upper Eocene and Middle Oligocene, Venezuela.
*Cassidulina angulosa* Cushman, **73,** 93, pl. 10, fig. 6. Recent, Tropical Pacific.
——— *costatula* Cushman, **73,** 94, pl. 10, fig. 7. Recent, Tropical Pacific.
——— *minuta* Cushman, **73,** 92, pl. 10, fig. 3. Recent, Tropical Pacific.
——— *norcrossi* Cushman, **77,** 7, pl. 2, fig. 7. Recent, Arctic, northeastern Greenland.
——— *patula* Cushman, **73,** 92, pl. 10, fig. 2. Recent, Tropical Pacific.
——— *rarilocula* Cushman, **73,** 93, pl. 10, fig. 4. Recent, Tropical Pacific.
——— *subtumida* Cushman, **73,** 93, pl. 10, fig. 5. Recent, Tropical Pacific.
**Cayeuxina** nov. gen., Galloway, **141,** 156. Fam. Endothyridae Rhumbler, 1895. Genoholotype: *C. precambrica* Galloway, 1933. Pre-Cambrian.
——— *precambrica* Galloway, **141,** 156, pl. 14, figs. 1–6. Pre-Cambrian, Brittany. [For figures given in Cayeux, 1894, *Soc. Géol. Nord, Annals*, vol. 22, p. 116, text figs. 1–6.]
**Chapmaniidae** nov. fam., Galloway, **141,** 316. Eocene and Oligocene.
*Cibicides americanus* (Cushman, 1918) var. *bonairensis* Pijpers, **278,** 74, text figs. 130–133. Upper Eocene, Bonaire.
——— *cooperensis* Cushman, **66,** 20, pl. 2, fig. 11. Upper Eocene, South Carolina.
——— *floridanus* (Cushman, 1918) var. *cushmani* Barbat and von Estorff, **15,** 173, pl. 23, fig. 21. Lower Miocene, California.
——— *megalocephalus* Pijpers, **278,** 74, text figs. 134–137. Upper Eocene, Bonaire.
**Cibicidinae** nov. subfam., Galloway, **141,** 290. Subfam. of Rotaliidae Reuss, 1860. Triassic to Recent.
*Clavulina arenata* Cushman, **70,** 54, pl. 6, fig. 5. Upper Cretaceous, Arkansas.
——— *disjuncta* Cushman, **67,** 22. [For *C. plummerae* Cushman, 1932, non Sandidge, 1932, *Jour. Paleontology*, vol. 6, p. 333,

pl. 50, fig. 1]. Upper Cretaceous, Texas.
*Climacammina* n. sp., Galloway, **142,** p. 5, fig. 2(7). Middle Pennsylvanian, Tairum Nor Basin, Inner Mongolia.
**Colania** nov. gen., Lee, **216,** 20. Fam. Fusulinidae Möller, 1878. Genotype: *C. kwangsiana* Lee, 1933. Permian, China.
——— *kwangsiana* Lee, **216,** 21, pl. 5, fig. 3. Permian, Kwangsi, China.
*Conicospirillina coronata* Cushman, **73,** 87, pl. 9, fig. 1. Recent, Tropical Pacific.
——— *semi-involuta* Cushman, **73,** 86, pl. 8, fig. 19. Recent, Tropical Pacific.
——— *trochoidea* Cushman, **73,** 87, pl. 8, fig. 20. Recent, Tropical Pacific. [Note: This specific name is a misnomer, because there exists already a *Conicospirillina trochoides* (Berthelin, 1879, *Spirillina*) according to Cushman, 1927, *Cushman Lab. Foram. Research, Contr.*, vol. 2, p. 74, pl. 16, fig. 2.]
*Cristellaria* (*Planularia*) *kochi* Pijpers, **278,** 61, text figs. 36–38. Upper Eocene, Bonaire. [Note: This species is preoccupied by *C. kochi* Reuss, 1865, *Denkschr. K. Akad. Wiss. Wien*, vol. 25, p. 139, pl. 2, fig. 35, Septarian clays, Germany.]
——— (*Saracenaria*) *macgillavryi* Pijpers, **278,** 63, text figs. 49–51. Upper Eocene, Bonaire.
——— (*Astacolus*) sp. Eichenberg, **114,** 175, pl. 19, fig. 11. Lower Cretaceous, Barremian, Germany.
——— ——— sp. Eichenberg, **114,** 176, pl. 23, fig. 4. Lower Cretaceous, Barremian, Germany.
——— (*Planularia*) sp. Pijpers, **278,** 62, text figs. 41, 42. Upper Eocene, Bonaire.
——— (*Saracenaria*) sp. Pijpers, **278,** 63, text figs. 52–54. Upper Eocene, Bonaire.
——— (*Planularia*) sp.? juv. of *Planularia thalmanni* Pijpers, **278,** 62, text figs. 43–45. Upper Eocene, Bonaire.
——— ——— *subminuta* Pijpers, **278,** 60, text figs. 34, 35. Upper Eocene, Bonaire.
——— ——— *thalmanni* Pijpers, **278,** 60, text figs. 27–29. Upper Eocene, Bonaire.
——— ——— ——— Pijpers, 1933, var. *costata* Pijpers, **278,** 60, text fig. 31. Upper Eocene, Bonaire.
——— ——— ——— Pijpers, 1933, var. *portospañoensis* Pijpers, **278,** 60, text fig. 30. Upper Eocene, Bonaire.
——— (*Saracenaria*) *vermunti* Pijpers, **278,** 63, text figs. 46–48. Upper Eocene, Bonaire.
——— (*Planularia*) *westermanni* Pijpers, **278,** 61, text figs. 39, 40. Upper Eocene, Bonaire.
*Cristellaria*, see also *Lenticulina*, *Saracenaria*, and *Robulus*.
**Cycloclypeidae** nov. fam., Galloway, **141,** 441. Late Cretaceous to Recent, mostly in Eocene.
*Cycloclypeus* sp. David, **89,** 126, pl. 10, fig. 1. Miocene, Burdigalian, Syria.
**Cycloclypsinella** nov. gen., Galloway, **141,** 138. Fam. Soritidae, Ehrenberg, 1840. Genotype: *Cyclopsina steinmanni* Munier-Chalmas, 1887. Upper Cretaceous, France.
**Cymbaloporidae** nov. fam., Cushman, **74,** 250. Upper Cretaceous to Recent.

*Dentalina cooperensis* Cushman, **66,** 8, pl. 1, fig. 17. Upper Eocene, South Carolina.
——— *doliiformis* Eichenberg, **113,** 7, pl. 7, fig. 6. Lower Cretaceous, Albian, Germany.
——— *halkyardi* Cushman, **66,** 9, pl. 1, fig. 20. Upper Eocene, South Carolina. [For *Nodosaria* (*Dentalina*) *spinulosa* Halkyard, 1919, *Manchester Lit. Philos. Soc., Mem. Proc.*, vol. 62, p. 79, non Montagu, 1808.]
——— *hantkeni* Cushman, **66,** 9, pl. 1, figs. 18, 19. Upper Eocene, Ocala limestone, Alabama.
——— *sidebottomi* Cushman, **76,** 12, pl. 3, fig. 4. Recent, Tropical Pacific. [For *Nodosaria radicula* Sidebottom, 1918, *Roy. Micros. Soc., Jour.*, pl. 4, figs. 1–5, non Linnaeus, 1758.]
——— sp.(?) Cushman, **76,** 13, pl. 3, fig. 5. Recent, Tropical Pacific.
——— sp. Eichenberg, **114,** 183, 184, 186. [Note: From the Lower Cretaceous Barremian of Germany. This author, using the nomenclatura aperta, mentions seven different forms: p. 183, pl. 18, fig. 1; p. 184, pl. 18, fig. 3; p. 184, pl. 18, fig. 4; p. 184, pl. 18, fig. 5; p. 186, pl. 19, fig. 4; p. 186, pl. 19, fig. 8 and p. 186, pl. 20, fig. 8.]
*Dentalina*, see also *Nodosaria*.
?*Dentalinopsis* n. sp. Eichenberg, **114,** 190, pl. 18, fig. 11, pl. 23, fig. 6. Lower Cretaceous, Barremian, Germany.
**Dentostomina** nov. gen., Carman, **41,** 31. Fam. Miliolidae, d'Orbigny, 1839. Genoholotype: *D. bermudiana* Carman, 1933. Recent, Bermuda.
——— *bermudiana* Carman, **41,** 31, pl. 3, fig. 6. Recent, shallow water, Bermuda.
*Discocyclina* (*Asterocyclina*) *kugleri* Gravell, **149,** 23, pl. 3, figs. 1–5. Upper Eocene, Venezuela.
——— sp. indet., Gravell, **149,** 21, pl. 2, figs. 8, 9. Middle Eocene, Venezuela.
*Discorbis alabamensis* Cushman, **66,** 16, pl. 2, fig. 3. Upper Eocene, Ocala limestone, Alabama.
——— *alveata* Cushman, **66,** 16, pl. 2, fig. 4. Upper Eocene, Mississippi.
——— *amundseni* Lipparini, 1932, **222,** 68, pl. 5, fig. 3. Upper Miocene, Italy.
——— *assulata* Cushman, **66,** 15, pl. 2, fig. 2. Upper Eocene, Ocala limestone, Georgia.
——— *bartletti* Cushman, **77,** 6, pl. 2, figs. 3–6. Recent, Arctic, Fox Basin.

——— *bulla* Cushman, **66,** 16, pl. 2, fig. 1. Upper Eocene, Ocala limestone, Alabama.
——— *crustata* Cushman, **73,** 88, pl. 9, fig. 4. Recent, Tropical Pacific.
——— *frustrata* Cushman, **73,** 88, pl. 9, fig. 2. Recent, Tropical Pacific.
——— *globulo-spinosa* Cushman, **66,** 14, pl. 2, fig. 1. Upper Eocene, Mississippi.
——— *margaritaceus* Earland, **110,** 125, pl. 4, figs. 23–25. Recent, Antarctic, South Georgia.
——— *micens* Cushman, **73,** 89, pl. 9, fig. 5. Recent, Tropical Pacific.
——— *ocalana* Cushman, **66,** 15, pl. 2, fig. 5. Upper Eocene, Ocala limestone, Florida.
——— *opima* Cushman, **73,** 88, pl. 9, fig. 3. Recent, Tropical Pacific.
*Dorothia glabrata* Cushman, **70,** 56, pl. 6, fig. 10. Upper Cretaceous, Texas.
——— *glabrella* Cushman, **70,** 56, pl. 6, fig. 9. Upper Cretaceous, Texas.
——— *pontoni* Cushman, **70,** 55, pl. 6, fig. 8. Upper Cretaceous, Mississippi.
*Dyocibicides rutteni* Pijpers, **278,** 74, text figs. 138–141. Upper Eocene, Bonaire.
——— *uniserialis* Thalmann, **345,** 254. Recent, West coast of New Zealand. [For *D.* n. sp. aff. *Truncatulina variabilis* Brady, 1884, Thalmann, 1932, non d'Orbigny, 1826.]

**Eggerella** nov. gen., Cushman, **68,** 33. Fam. Valvulinidae Cushman, 1927. Genotype: *Verneuilina bradyi* Cushman, 1911. Cretaceous to Recent.
*Ehrenbergina albatrossi* Cushman, **73,** 94, pl. 10, fig. 8. Recent, Tropical Pacific.
——— *reticulata* Cushman, **73,** 94, pl. 10, fig. 9. Recent, Tropical Pacific.
*Ellipsolingulina silvestrii* Galloway, **141,** 386, pl. 35, fig. 12. Oligocene, Italy. [For *E. impressa* Silvestri, 1907, *Riv. Ital. Pal.*, vol. 13, pp. 66–69, text fig. 2; non text fig. 1, non Terquem, 1882.]
*Ellipsopolymorphina fornasinii* Galloway, **141,** 382, pl. 35, fig. 4. Pliocene, Italy. [For *Dimorphina deformis* Fornasini, 1890, *Mem. R Acc. Sci. Ist. Bologna, Sez. Sci. Nat.*, (4), vol. 10, p. 471, figs. 35–37, non *Glandulina deformis* Costa, 1856.]
**Elphidiinae** nov. subfam., Galloway, **141,** 269. Subfam. of Nonionidae Reuss, 1860. Jurassic to Recent.
*Elphidium advenum* Cushman, 1922, var. *depressulum* Cushman, **76,** 51, pl. 12, fig. 4. Recent, Tropical Pacific.
——— *bartletti* Cushman, **77,** 4, pl. 1, fig. 9. Recent, Arctic, Labrador.
——— *frigidum* Cushman, **77,** 5, pl. 1, fig. 8. Recent, Arctic, Fox Basin.
——— *groenlandicum* Cushman, **77,** 4, pl. 1, fig. 10. Recent, Arctic, northeast Greenland.
——— *oceanicum* Cushman, **76,** 52, pl. 12, fig. 7. Recent, Tropical Pacific. [For *Polystomella* sp.(?) Cushman, 1924, *Carnegie Inst. Washington, Pub.* 342, p. 49, pl. 16, fig. 5.]
——— *reticulosum* Cushman, **76,** 51, pl. 12, fig. 5. Recent, Tropical Pacific.
——— *simplex* Cushman, **76,** 52, pl. 12, figs. 8, 9. Recent, Tropical Pacific.
——— *subevolutum* Cushman, **76,** 52, pl. 12, fig. 6. Recent, Tropical Pacific.
*Endothyra* sp. Galloway, **142,** 4, fig. 2, Nos. 1 and 2. Middle Pennsylvanian, Tairum Nor Basin, Inner Mongolia.
*Eouvigerina aculeata* Cushman, **70,** 62, pl. 7, fig. 8. Upper Cretaceous, Texas.
——— *austinana* Cushman, **70,** 61, pl. 7, fig. 5. Upper Cretaceous, Texas.
——— *plummerae* Cushman, **70,** 62, pl. 7, figs. 6, 7. Upper Cretaceous, Texas.
**Eoverbeekina** nov. gen. Lee, **216,** 18. Fam. Fusulinidae Möller, 1878. Genotype: *E. intermedia* Lee, 1933. Permian, China.
——— *intermedia* Lee, **216,** 18, 19, pl. 1, figs. 4, 4*a*; pl. 2, figs. 1–3. Permian, Kweichow, China.
**Epistomaria** nov. gen., Galloway, **141,** 286. Fam. Rotaliidae Reuss, 1860. Genoholotype: *Discorbina rimosa* Parker and Jones, 1862. Eocene, Paris Basin; Recent, India and Australia.
*Eponides fijiana* Cushman, **73,** 89, pl. 9, fig. 6. Recent, Tropical Pacific.
——— *minima* Cushman, **66,** 17, pl. 2, fig. 8. Upper Eocene, South Carolina.
——— n. sp. Eichenberg, **113,** 21, pl. 7, fig. 5. Lower Cretaceous, Albian, Germany.
——— *ocalana* Cushman, **66,** 17, pl. 2, fig. 7. Upper Eocene, Ocala limestone, Alabama.
——— *terebra* Cushman, **73,** 89, pl. 10, fig. 1. Recent, Tropical Pacific.

*Flintia soluta* Earland, **110,** 47, pl. 1, figs. 1–4. Recent, Antarctic, South Georgia.
*Frankeina* sp.? Wickenden, **385,** 158, pl. 1, fig. 2. Jurassic, Canada.
*Frondicularia* n. sp., Eichenberg, **114,** 189, pl. 20, fig. 5. Lower Cretaceous, Barremian, Germany.
——— *phosphatica* Russo, 1933, **304,** 358, pl. 16, figs. 6–8. Upper Cretaceous, Maestrichtian, Central Morocco.
——— *rehamnae* Russo, 1932, **304,** 357, pl. 16, figs. 1–5. Upper Cretaceous, Maestrichtian, Central Morocco. [Note: This new species was already described and figured by the same author in 1932.]
——— *varians* Russo, **304,** 359, pl. 16, fig. 10. Upper Cretaceous, Central Morocco.
——— *vertebralis* Russo, **304,** 358, pl. 15, fig. 9. Upper Cretaceous, Maestrichtian, Central Morocco.

*Gaudryina bonairensis* Pijpers, **278,** 59, text figs. 20, 21. Upper Eocene, Bonaire.

——— *io* Cushman, **70,** 51, pl. 5, fig. 6. Upper Cretaceous, Texas.
——— *subquadrata* Cushman, **66,** 2, pl. 1, fig. 1. Upper Eocene, South Carolina.
*Gaudryinella capitosa* Cushman, **70,** 52, pl. 5, fig. 8. Upper Cretaceous, Mississippi.
——— *capitosa* Cushman, 1933, var *serrulata* Cushman, **70,** 52, pl. 5, fig. 9. Upper Cretaceous, Texas.
——— *mollis* Cushman, **70,** 53, pl. 6, fig. 6. Upper Cretaceous, Texas.
*Globigerina* sp.? Wickenden, **385,** 168, pl. 2, fig. 16. Jurassic, Canada.
*Globorotalia bonairensis* Pijpers, **278,** 71, text figs. 107–110. Upper Eocene, Bonaire.
——— *kochi* Pijpers, **278,** 71, text figs. 111–115. Upper Eocene, Bonaire.
*Glomospira biplana* Moreman, **246,** 397, pl. 47, fig. 9. Paleozoic, Oklahoma; no locality or formation mentioned.
**Goësella** nov. gen., Cushman, **68,** 34. Fam. Valvulinidae Cushman, 1927. Genotype: *Clavulina rotundata* Cushman, 1913. Recent, and probably older.
——— *rugulosa* Cushman, **68,** 55, pl. 6, fig. 7. Upper Cretaceous, Mississippi.
*Gordiospira arctica* Cushman, **77,** 3, pl. 1, figs. 5–7. Recent, Antarctic, northeast Greenland.
*Gümbelina goodwini* Cushman and Jarvis, **71,** 69, pl. 7, figs. 15, 16. Upper Eocene, Trinidad.
**Gümbelitria** nov. gen., Cushman, **68,** 37. Fam. Heterohelicidae Cushman, 1927. Genoholotype: *G. cretacea* Cushman, 1933. Upper Cretaceous.
——— *cretacea* Cushman, **68,** 37, pl. 4, fig. 12. Upper Cretaceous, Texas.
**Gunteria** nov. gen., Cushman and Ponton, **81,** 25. Fam. Valvulinidae Cushman, 1927. Genoholotype: *G. floridana* Cushman and Ponton, 1933. Middle Eocene.
——— *floridana* Cushman and Ponton, **81,** 25, 26, pl. 3, figs. 1–3. Middle Eocene, Florida.
*Guttulina* sp.(?) Cushman, **76,** 38, pl. 9, fig. 10. Recent, Tropical Pacific.
——— sp.? Wickenden, **385,** 167, pl. 2, fig. 13. Jurassic, Canada.

**Hagenowella** nov. gen., Cushman, **69,** 42. Fam. Valvulinidae, Cushman, 1927. Genoholotype: *Valvulina gibbosa* d'Orbigny, 1840. Upper Cretaceous. (See also: *Am. Jour. Sci.*, vol. 26, p. 21, pl. 1, figs. 1–3.)
*Haplophragmoides* sp. Eichenberg, **114,** 169, pl. 23, fig. 2. Lower Cretaceous, Barremian, Germany.
——— sp.? Wickenden, **385,** 158, pl. 1, fig. 4. Jurassic, Canada.
*Haplostiche* sp. Eichenberg, **113,** 4, pl. 1, fig. 4. Lower Cretaceous, Albian, Germany.
*Hastigerinella rhumbleri* Galloway, **141,** 333, pl. 30, fig. 9. Recent, Atlantic. [For *Hastigerina digitata* Rhumbler, 1909 (1911), *Foram. Planton-Exped.*, pt. 1, p. 202, pl. 37, figs. 9, 10. This species is designated as the genoholotype.]
*Hemigordius lilydalensis* Chapman, **50,** 246, pl. 11, fig. 2. Silurian, Lilydale, Australia.
*Heterostegina gigantea* David, **90,** 125, pl. 8, fig. 3. Miocene, Burdigalian, Djebel Abiad, Syria.
——— *panamensis* Gravell, **149,** 17, pl. 1, figs. 10, 11. Middle Oligocene, Venezuela. [For *H.* sp. Vaughan, 1924, *Geol. Soc. America, Bull.*, vol. 35, p. 789.]
**Heterostegininae** nov. subfam., Galloway, **141,** 421. Subfam. of Camerinidae Meek and Hayden, 1865. Upper Cretaceous to Recent.
*Heterostomella austinana* Cushman, **70,** 53, pl. 6, figs. 1–3. Upper Cretaceous, Texas.
——— *cuneata* Sandidge, 1932, var. *curvata* Cushman, **70,** 54, pl. 6, fig. 4. Upper Cretaceous, Mississippi.
*Hippocrepina bendensis* Harlton, **159,** 9, pl. 2, fig. 7. Pennsylvanian, Oklahoma. [For *Stacheia marginulinoides* Galloway and Harlton, 1928, *Jour. Paleontology*, vol. 2, p. 356, pl. 46, fig. 6, non Brady.]
*Hopkinsina pacifica* Cushman, **73,** 86, pl. 8, fig. 16. Recent, Tropical Pacific.
*Hyperammina hastula* Moreman, **246,** 396, pl. 47, fig. 2. Middle Silurian, Oklahoma.
——— *johnsvalleyensis* Harlton, **159,** 8, pl. 1, fig. 1. Pennsylvanian, Oklahoma.
——— sp. (n. sp.?) Eichenberg, **113,** 2, pl. 1 fig. 6. Lower Cretaceous, Albian, Germany.

*Isolepidina mauretanica* Bourcart and David, **35,** 48, pl. 3, fig. 2; pl. 4, fig. 1; pl. 6, fig. 2; pl. 12, figs. 4, 5; text fig. 3. Eocene, Priabonian, Ouezzan, Morocco.

**Karreriella** nov. gen., Cushman, **68,** 34. Fam. Valvulinidae Cushman, 1927. Genotype: *Gaudryina siphonella* Reuss, 1851. Eocene to Recent.
**Kerionammina** nov. gen., Moreman, **246,** 397. Fam. Neusinidae Cushman, 1910. Genotype: *K. favus* Moreman, 1933. Upper Ordovician, Oklahoma.
——— *favus* Moreman, **246,** 397, pl. 47, figs. 1, 3. Upper Ordovician, Viola formation, Oklahoma.

*Lagena formosa* Schwager, 1866, var. *costata* Earland, **110,** 111, pl. 4, figs. 16–18. Recent, Antarctic, South Georgia.
——— *hartiana* Earland, **110,** 112, pl. 4, figs. 12, 13. Recent, Antarctic, South Georgia.
——— *herdmani* Earland, **110,** 112, pl. 4, figs. 10, 11. Recent, Antarctic, South Georgia.
——— *mackintoshiana* Earland, **110,** 114, pl. 4, figs. 14, 15. Recent, Antarctic, South Georgia.

——— *orbignyana* (Seguenza, 1862) var. *semiconcentrica* Cushman, **66,** 10, pl. 1, fig. 22. Upper Eocene, North Carolina.
——— *sigmoidella* Cushman, **76,** 23, pl. 5, figs. 10, 11. Recent, Tropical Pacific.
——— (?) sp. Cushman, **76,** 38, pl. 6, fig. 12. Recent, Tropical Pacific.
——— spec. R. E. and K. C. Stewart, **333,** 266, pl. 17, figs. 2, 3. Upper Pliocene, California.
*Lagenammina cucurbita* Moreman, **246,** 395, pl. 47, fig. 5. Middle Silurian, Oklahoma.
**Lagyninae** nov. subfam., Galloway, **141,** 41. Subfam. of Lagynidae Schultze, 1854. Recent, shallow marine and fresh or salt inland water.
*Lamarckina jacksonensis* Cushman, **66,** 20, pl. 2, fig. 10. Upper Eocene, Ocala limestone, Alabama.
——— *vermunti* Pijpers, **278,** 70, text figs. 100–103. Upper Eocene, Bonaire.
**Leeina** nov. gen., Galloway, **141,** 406. Fam. Fusulinidae, Möller, 1878. Genotype: *Fusulina vulgaris fusiformis* Schellwien, 1909. Upper Pennsylvanian and Permian.
*Lenticulina frankei* Eichenberg, **113,** 16, pl. 6, fig. 2. Lower Cretaceous, Albian, Germany.
——— n. sp., Eichenberg, **113,** 16, pl. 6, fig. 3. Lower Cretaceous, Albian, Germany.
——— sp. Eichenberg, **113,** 15, pl. 8, fig. 6. Lower Cretaceous, Albian, Germany.
——— ? sp. Wickenden, **385,** 160, pl. 1, fig. 8. Jurassic, Canada.
——— sp. (n. sp.?), Eichenberg, **114,** 172, pl. 21, fig. 2. Lower Cretaceous, Barremian, Germany.
*Lepidocyclina antiguensis* Vaughan and Cole, in Vaughan, **364,** 19, pl. 10, fig. 8; pl. 24, figs. 2, 3. Middle Oligocene, Antigua formation, Antigua.
——— (*Nephrolepidina*?) *crassimargo* Vaughan, **364,** 33, pl. 27, figs. 1–3. Oligocene, probably Upper Oligocene, Cuba.
——— ——— *dartoni* Vaughan, **364,** 36, pl. 25, figs. 1, 2; pl. 26, figs. 1–3. Oligocene, Cuba.
——— *hodgensis* Vaughan and Cole, in Vaughan, **364,** 23, pl. 12, figs. 1–5. Upper Oligocene, Antigua.
——— (*Lepidocyclina*) *meinzeri* Vaughan, **364,** 11, pl. 3, figs. 1, 2; pl. 4, fig. 1, 2*c*, 3–5. Eocene, probably upper Eocene, Cuba.
——— ——— *novitasensis* Vaughan, **364,** 8, pl. 1, figs. 1–4. Eocene, probably upper Eocene, Cuba. [For *Orthophragmina pustulata* Cushman, 1919, *Carnegie Inst. Washington, Pub.* 291, pl. 9, fig. 6 (non fig. 7), and *Orthophragmina sculpturata* Cushman, 1920, *U. S. Geol. Survey, Prof. Paper* 124, pl. 8, fig. 3 (non pl. 9, figs. 4–7).
——— ——— *parvula* Cushman, 1919, var. *crassicosta* Vaughan and Cole, in Vaughan, **364,** 17, pl. 8, figs. 1, 2; pl. 24, fig. 1. Middle to Upper Oligocene, Antigua formation, Antigua.
——— (*Nephrolepidina*) *piedrasensis* Vaughan, **364,** 34, pl. 27, fig. 4. Oligocene, probably Upper Oligocene, Cuba.
——— (*Lepidocyclina*) *sanluisensis* Gravell, **149,** 27, pl. 4, figs. 1–4. Middle Oligocene, Venezuela.
——— (*Nephrolepidina*) *semmesi* Vaughan and Cole, in Vaughan, **364,** 29, pl. 15, figs. 3–5; pl. 30, fig. 1; pl. 31, figs. 1, 1*a*; pl. 32, figs. 2, 3. Upper Eocene, Tantoyuca formation, eastern Mexico.
——— ——— ——— Vaughan and Cole, 1933, var. *granosa* Vaughan and Cole, in Vaughan, **364,** 30, pl. 30, fig. 2. Upper Eocene, Tantoyuca formation, eastern Mexico. [For *L. ocalana* Cushman, 1920, var. *subdecorata* Nuttall, 1930, *Jour. Paleontology*, vol. 4, p. 273, non Cushman, 1920.]
——— ——— sp. Gravell, **149,** 31, pl. 5, figs. 9, 10; pl. 6, fig. 1. Middle Oligocene, Venezuela.
——— ——— sp. Vaughan, **364,** 35, pl. 21, fig. 2; pl. 32, fig. 1. Middle Oligocene, Meson formation, eastern Mexico. [For *L.* (*N.*) *marginata* (Mich.) in Vaughan, 1924, *Geol. Soc. America, Bull.*, vol. 35, p. 798, pl. 34, fig. 1.]
——— (*Lepidocyclina*) sp. indet. (a) Gravell, **149,** 28 (no fig. given). Middle and Upper Oligocene, Venezuela.
——— sp. indet. a. Vaughan, **364,** 42, pl. 26, fig. 5. Oligocene, Cuba.
——— sp. indet. b. Vaughan, **364,** 43, pl. 23, figs. 4, 5. Middle Oligocene, Cuba.
——— sp. indet. (b) Gravell, **149,** 29 (no fig. given). Middle Oligocene, Venezuela.
——— sp. indet. c. Vaughan, **364,** 43, pl. 23, figs. 6–8. Probably Oligocene, Cuba.
——— ? sp. indet. d. Vaughan, **364,** 44, pl. 25, fig. 3. Oligocene, probably Upper Oligocene, Cuba. This form is only questionably referred to the genus *Lepidocyclina* by the author.
——— (*Nephrolepidina*) *tantoyucensis* Vaughan and Cole, in Vaughan, **364,** 30, pl. 15, figs. 1, 2. Upper Eocene, Tantoyuca formation, eastern Mexico. [For *L. ocalana* Nuttall, 1930, *Jour. Paleontology*, vol. 4, p. 273, non Cushman, 1920.]
——— ——— *tempanii* Vaughan and Cole, in Vaughan, **364,** 26, pl. 13, figs. 3–6. Upper Oligocene, Antigua.
——— (*Lepidocyclina*)*wetherellensis* Vaughan and Cole, in Vaughan, **364,** 24, pl. 12, figs. 6, 7; pl. 23, figs. 9, 10; pl. 24, fig. 5. Middle Oligocene, Antigua formation, Antigua.
——— ——— *yurnagunensis* Cushman, 1919, var. *morganopsis* Vaughan, **365,** 261; **366,** 354. See Vaughan, **364,** 22, pl. 11, figs. 5–9; pl. 23, figs. 1–3. Middle Oligocene, Cuba. [For *L. morgani* Cushman, 1919, *Carnegie*

*Inst. Washington, Pub.* 291, p. 59, pl. 11, figs. 1–3, text fig. 7, non Lemoine and R. Douvillé, 1904; and *L. morgani* Cushman, 1920, *U. S. Geol. Survey, Prof. Paper* 125, p. 74, pl. 33, figs. 12–14, non Lemoine and R. Douvillé, 1904.]

*Lepidocyclina*, see also *Isolepidina* and *Nephrolepidina*.

**Lepidolina** nov. gen., Lee, **216,** 21. Fam. Fusulinidae Möller, 1878. Genotype: *Neoschwagerina* (*Sumatrina*) *multiseptata* Deprat, 1912. Permian, China.

**Lepidorbitoidinae** nov. subfam., Vaughan, **368,** 282 (in Cushman, **74**). Upper Cretaceous of Europe and India.

**Liebusella** nov. gen., Cushman, **68,** 36. Fam. Valvulinidae Cushman, 1927. Genotype: *Lituola soldanii* Jones and Parker, 1860. Eocene to Recent.

**Listerella** nov. gen., Cushman, **68,** 36. Fam. Valvulinidae Cushman, 1927. Genotype: *Clavulina primaeva* Cushman, 1913. Eocene to Recent.

*Lituotuba dubia* Miller and Carmer, **242,** 430, pl. 50, fig. 11. Devonian, Iowa.

——— sp. Vanderpool, **363,** 409, pl. 49, fig. 12. Lower Cretaceous, southern Oklahoma.

*Loxostoma rostrum* Cushman, **73,** 82, pl. 8, fig. 13. Recent, Tropical Pacific.

*Marginulina cooperensis* Cushman, **66,** 8, pl. 1, figs. 14, 15. Upper Eocene, South Carolina.

——— *cooperi* Cushman, **66,** 5, pl. 1, fig. 13. Upper Eocene, South Carolina.

——— sp. Eichenberg, **113,** 10, pl. 2, fig. 22. Lower Cretaceous, Albian, Germany.

——— sp. Eichenberg, **114,** 176, pl. 21, fig. 1. Lower Cretaceous, Barremian, Germany.

——— sp. Eichenberg, **114,** 177, pl. 20, fig. 2. Lower Cretaceous, Barremian, Germany.

——— sp. Eichenberg, **114,** 178, pl. 19, fig. 6. Lower Cretaceous, Barremian, Germany.

——— sp. Eichenberg, **114,** 178, pl. 23, fig. 9. Lower Cretaceous, Barremian, Germany.

——— sp. Eichenberg, **114,** 179, pl. 19, fig. 9. Lower Cretaceous, Barremian, Germany.

——— sp. (n. sp.?) Eichenberg, **114,** 176, pl. 20, fig. 1. Lower Cretaceous, Barremian, Germany.

——— sp. (sp. n.?) Eichenberg, **113,** 10, pl. 7, fig. 4. Lower Cretaceous, Albian, Germany.

——— ? sp. Wickenden, **385,** 163, pl. 1, fig. 12. Jurassic, Canada.

*Marsipella aggregata* Moreman, **246,** 395, pl. 47, figs. 11, 12. Upper Ordovician, Oklahoma.

**Marssonella** nov. gen., Cushman, **68,** 36. Fam. Valvulinidae Cushman, 1927. Genotype: *Gaudryina oxycona* Reuss, 1860. Cretaceous to Recent.

**Martinottiella** nov. gen., Cushman, **68,** 37. Fam. Valvulinidae Cushman, 1927. Genotype: *Clavulina communis* d'Orbigny, 1826. Cretaceous to Recent.

*Massilina glutinosa* Cushman and Cahill, **79,** 10, pl. 2, fig. 10. Miocene, Coastal Plain, U.S.A.

——— *jacksonensis* Cushman, **66,** 2, pl. 1, fig. 4. Upper Eocene, Mississippi. [Note: This species name is preoccupied by Cushman, 1927, *Jour. Paleontology*, vol. 1, p. 150, pl. 23, figs. 5, 6.]

——— ——— Cushman, 1933 (non Cushman, 1927) var. *punctato-costata* Cushman, **66,** 3, pl. 1, figs. 5, 6. Upper Eocene, Mississippi. [Note: The specific name *jacksonensis* is already preoccupied by the same author in 1927. This variety must, therefore, belong to a species to be renamed.]

——— *mansfieldi* Cushman and Cahill, **79,** 11, pl. 2, fig. 11. Miocene, Coastal Plain, U.S.A.

——— *marylandica* Cushman and Cahill, **79,** 10, pl. 2, fig. 9. Miocene, Coastal Plain, U. S. A.

**Matthewina** nov. gen., Galloway, **141,** 157. Fam. Endothyridae Rhumbler, 1895. Genotype: *Globigerina cambrica* Matthew, 1895. Upper and Middle Cambrian.

*Miliammina cribrosa* Earland, **110,** 90. [For *Miliolina alveoliniformis* Brady, 1881, in Fauré Fremiet, 1914, *Deuxième Expéd. Antarct. Franç.* (1908–10), Foram., p. 4, pl. O, fig. 5.] Recent, Antarctic.

*Miliola jacksonensis* Cushman, **66,** 2, pl. 1, figs. 2, 3. Upper Eocene, Mississippi.

*Millettella spinata* Cushman and Cahill, **79,** 5, pl. 1, fig. 3. Miocene, Coastal Plain, U. S. A.

*Mimosina pacifica* Cushman, **73,** 77, pl. 8, fig. 3. Recent, Tropical Pacific.

**Miniacina** nov. gen., Galloway, **141,** 305. Fam. Acervulinidae Schultze, 1854. Genotype: *Millepora miniacea* Pallas, 1766. Eocene to Recent.

*Miogypsina bramlettei* Gravell, **149,** 32, pl. 6, figs. 5–10. Middle or Upper Oligocene, Venezuela.

——— *mexicana* Nuttall, **266,** 175, pl. 24, figs. 1–6, 8, 10, 12. Oligocene, Mexico.

**Nankinella** nov. gen., Lee, **216,** 14–16. Fam. Fusulinidae Möller, 1878. Genotype: *Staffella discoides* Lee, 1931. Permian, China.

——— *orbicularia* Lee, **216,** 16, pl. 2, figs. 4, 4*a*; pl. 3, figs. 1, 2. Lower Permian, southern China.

**Nannoconus** nov. gen., Kamptner, 1931, **189,** 289. Probably belongs to the family of the Lagenidae. Genotype: *N. steinmanni* Kamptner, 1931. Lower Cretaceous, Majolica-Biancone, Tithonian-Barremian, of Mt. Pavione, Italy.

——— *steinmanni* Kamptner, 1931, **189,** 289, text figs. 2, 3. Jurassic to Lower Cretaceous Tithonian-Barremian, Italy. This form

most probably is identical with *Lagena colomi* de Lapparent, 1931.
*Nephrolepidina tournoueri* (Lemoine and R. Douvillé, 1904) var. *exilis* David, **90,** 128, no fig. given. Miocene, Burdigalian, Chedjri, Syria.
*Nephrolepidina*, see also *Lepidocyclina*.
*Nodogenerina cooperensis* Cushman, **66,** 11, pl. 1, fig. 27. Upper Eocene, South Carolina.
——— ? *milletti* Cushman, **73,** 86, pl. 8, figs. 17, 18. Recent, Tropical Pacific. [For *Sagrina nodosa* Millett, 1903, *Roy. Micros. Soc., Jour.*, p. 271, pl. 5, figs. 12–15, non Parker and Jones, 1865.]
*Nodosarella gracillima* Cushman, **70,** 64, pl. 7, fig. 14. Upper Cretaceous, Texas.
*Nodosaria cookei* Cushman, **66,** 9, pl. 1, fig. 21. Upper Eocene, Ocala limestone, Alabama.
——— *latejugata* Gümbel, 1868, var. *carolinensis* Cushman, **66,** 5, pl. 1, fig. 16. Upper Eocene, South Carolina.
——— n. sp. 1 Eichenberg, **114,** 180, pl. 18, fig. 7. Lower Cretaceous, Barremian, Germany.
——— n. sp. 2 Eichenberg, **114,** 181, pl. 19, fig. 2. Lower Cretaceous, Barremian, Germany.
——— n. sp. 3 Eichenberg, **114,** 181, pl. 22, fig. 3. Lower Cretaceous, Barremian, Germany.
——— n. sp. 4 Eichenberg, **114,** 182, pl. 22, fig. 4. Lower Cretaceous, Barremian, Germany.
——— *prava* Cushman, **76,** 14, pl. 4, figs. 1–4. Recent, Tropical Pacific.
——— *rutteni* Pijpers, **278,** 64, text fig. 57. Upper Eocene, Bonaire.
——— ? sp. Barbat and von Estorff, **15,** 169, pl. 23, fig. 15. Lower Miocene, California.
——— sp. (?) Cushman, **76,** 14, pl. 3, fig. 11. Recent, Tropical Pacific.
——— ? sp. Wickenden, **385,** 166, pl. 2, fig. 7. Jurassic, Canada.
——— (*Dentalina*) sp. Pijpers, **278,** 65, text figs. 62, 63. Upper Eocene, Bonaire.
——— ——— *verneuili* d'Orbigny, 1846, var. *paucicostata* Pijpers, **278,** 64, text figs. 58, 59. Upper Eocene, Bonaire.
*Nonion bonairensis* Pijpers, **278,** 65, text figs. 68–70. Upper Eocene, Bonaire.
——— *hummelincki* Pijpers, **278,** 66, text figs. 71–73. Upper Eocene, Bonaire.
*Nonionella austinana* Cushman, **70,** 57, pl. 7, fig. 2. Upper Cretaceous, Texas.
——— *cockfieldensis* Cushman and Ellisor, **80,** 95, pl. 10, fig. 11. Eocene, Claiborne, Texas.
——— *cushmani* R. E. and K. C. Stewart, **333,** 264, pl. 17, figs. 1*a–c*. Upper Pliocene, California.
——— *jacksonensis* Cushman, **66,** 10, pl. 1, fig. 23. Upper Eocene, Alabama.
——— (?) sp. Cushman, **76,** 46, pl. 11, fig. 3. Recent, Tropical Pacific.
——— *translucens* Cushman, **76,** 45, pl. 11, fig. 2. Recent, Tropical Pacific.
*Nummulites brongniarti* d'Archiac and Haime, 1853, var. *bourcarti* Abrard, **4,** in Bourcart and David, **35,** 58, pl. 12, figs. 6–9. Eocene, Lutetian, Tangier, Morocco.
——— *mefferti* Panteléeff, **270,** 445, 453. Forma A: pl. 1, figs. 6–9; forma B: pl. 1, figs. 1–5. Upper Cretaceous, Danian, Létehkhume, western Georgia.
——— *subbolcensis* de Cizancourt, **56,** 362, pl. 17, figs. 2, 4. Eocene, Ypresian, Gzouli, Morocco. [For *N. bolcensis* P. Oppenheim, 1894, *Numm. Venez. Tertiär*, p. 25, text figs. 1–3, non Munier-Chalmas, 1878.]
——— *varnensis* Gočev, **145,** 23, 69, pl. 1, figs. 1–4, 9 (B-form), figs. 5–8 (A-form). Eocene, Lutetian, Bulgaria.
*Nummulites*, see also *Camerina*.

*Operculina alpanensis* Panteléeff, **270,** 450, 455, pl. 1, figs. 10–20. Upper Cretaceous, Danian, Létehkhuma, western Georgia.
——— *bonairensis* Pijpers, **278,** 56, text figs. 32, 33. Upper Eocene, Bonaire.
——— *heterosteginoides* Hofker, **169,** 148, pl. 6, figs. 1, 2, text fig. 33. Recent, Malay Archipelago.
——— sp. David, **90,** 122, pl. 8, fig. 4. Miocene, Burdigalian, Djebel Bichri, Syria.
*Orbitoides antiochena* David, **89,** 56, pl. 3, fig. 5. Upper Cretaceous, Maestrichtian, western Syria.
**Orbitolinopsis** nov. gen., Silvestri, 1932, *Palaeont. Italiana*, vol. 32, n.s., vol. 2, anno 1931, Siena 1932, p. 160. [For *Orbitolina conulus* Douvillé, ? *kiliani* Prever and *O.? silvestrii* Prever.] Barremian.

**Paalzowella** nov. gen., Cushman, **74,** 234. Fam. Rotaliidae Reuss, 1860. Genotype: *Discorbis scalariformis* Paalzow, 1917. Jurassic, Germany.
**Palaeobigenerina** nov. gen., Galloway, **141,** 223. Fam. Textulariidae d'Orbigny, 1846. Genotype: *Bigenerina geyeri* Schellwien, 1898. Pennsylvanian.
*Palaeotextularia* sp. Harlton, **159,** 11, pl. 2, fig. 6. Pennsylvanian, Oklahoma.
**Palaeotextulariinae** nov. subfam., Galloway, **141,** 221. Subfam. of Textulariidae d'Orbigny, 1846. Ordovician and Permian.
*Patellina advena* Cushman, 1922, var. *altiformis* Cushman, **73,** 87, pl. 9, fig. 8. Recent, Tropical Pacific.
*Patellinella fijiana* Cushman, **73,** 87, pl. 9, fig. 7. Recent, Tropical Pacific.
*Pavonina triformis* Parr, **273,** 29, pl. 7, figs. 1–3. Miocene, Victoria, Australia. [For *P. flabelliformis* Howchin, 1889, *Roy. Soc. South Australia, Trans.*, vol. 12, p. 7, non d'Orbigny, 1826; and *P. flabelliformis*

Heron-Allen and Earland, 1924, *Roy. Micro. Soc., Jour.*, p. 141, pl. 8; fig. 22, non d'Orbigny, 1826.]

*Pelosina fusiformis* Earland, **110,** 55, pl. 1, figs. 10–12. Recent, Antarctic, South Georgia.

——— *variabilis* Brady, 1879, var. *constricta* Earland, **110,** 55, pl. 1, figs. 13–15. Recent, Antarctic, South Georgia.

**Pernerina** nov. gen., Cushman, **78,** 44. Fam. Valvulinidae Cushman, 1927. Genoholotype: *Bulimina depressa* Perner, 1892. Upper Cretaceous, Bohemia.

**Pisolina** nov. gen., Lee, **216,** 19. Fam. Fusulinidae Möller, 1878. Genotype: *P. excessa* Lee, 1933. Lower Permian, China.

——— *excessa* Lee, **216,** 19, pl. 3, figs. 3, 3*a*, 3*b*. Lower Permian, Mitsang Gorge, China.

**Planorbulininae** nov. subfam., Galloway, **141,** 297. Subfam. of Rotaliidae Reuss, 1860. Upper Cretaceous to Recent.

*Planularia cooperensis* Cushman, **66,** 5, pl. 1, fig. 10. Upper Eocene, South Carolina.

——— *magnifica* Thalmann, **345,** 255. Recent, Fiji. [For *P.* n. sp. Thalmann, 1932, aff. *Cristellaria dentata* Brady, 1884, non Karrer, 1867.]

——— *magnifica* Thalmann, 1933, var. *elongata* Thalmann, **345,** p 255. Recent, Faroe Channel. [For *P.* n. sp. Thalmann, 1932, aff. *Cristellaria compressa* Brady, 1884, non d'Orbigny, 1846.]

*Planularia*, see also *Cristellaria*.

*Planulina cocoaensis* Cushman, 1928, var. *cooperensis* Cushman, **66,** 20, pl. 2, fig. 12. Upper Eocene, South Carolina.

——— sp. Vanderpool, **363,** 408, pl. 49, figs. 10, 11. Lower Cretaceous, southern Oklahoma.

*Plectina watersi* Cushman, **70,** 57, pl. 7, fig. 1. Upper Cretaceous, Texas.

*Plectofrondicularia cookei* Cushman, **66,** 11, pl. 1, fig. 26. Upper Eocene, South Carolina.

——— n. sp., Barbat and von Estorff, **15,** 170, pl. 23, fig. 5. Lower Miocene, California.

——— *rutteni* Pijpers, **278,** 66, text figs. 74, 75. Upper Eocene, Bonaire.

——— sp. Pijpers, **278,** 66, text fig. 76. Upper Eocene, Bonaire.

*Pleurostomella austinana* Cushman, **70,** 64, pl. 7, fig. 13. Upper Cretaceous, Texas.

——— *watersi* Cushman, **70,** 63, pl. 7, figs. 11, 12. Upper Cretaceous, Texas.

*Polydiexodina persica* Kahler, **188,** 168, pl. 17, figs. 1, 2. Upper Permian, Darreh-Duzdan, Persia.

**Praealveolina** nov. gen., Reichel, **294,** 270. Fam. Alveolinellidae Cushman, 1928. Genotype: *P. tenuis* Reichel, 1933. Cretaceous, Cenomanian.

——— *tenuis* Reichel, **294,** 270, text figs. 10–14. Upper Cretaceous, Cenomanian, Basin of Beausset, France.

*Proteonina decorata* Earland, **110,** 62, pl. 1, figs. 28, 29. Recent, Antarctic, South Georgia.

**Proteonininae** nov. subfam., Galloway, **141,** 65. Subfam. of Astrorhizidae Brady, 1881. Silurian, Jurassic and Recent.

*Pullenia octolobe* Barbat and von Estorff, **15,** 173, pl. 23, fig. 11. Lower Miocene, California.

*Pulvinulinella pulchra* Cushman, **73,** 92, pl. 9, fig. 10. Recent, Tropical Pacific.

——— *umbonifera* Cushman, **73,** 90, pl. 9, fig. 9. Recent, Tropical Pacific.

*Quinqueloculina arctica* Cushman, **77,** 2, pl. 1, fig. 3. Recent, Arctic, northeastern Greenland.

——— *fusca* Brady, 1870, var. *groenlandica* Cushman, **77,** 2, pl. 1, fig. 4. Recent, Arctic, northeastern Greenland.

*Ramulina* sp. Vanderpool, **363,** 408, pl. 49, fig. 13. Lower Cretaceous, southern Oklahoma.

*Reophax ammobaculitiformis* Hofker, **169,** 76, text fig. 2. Recent, Malay Archipelago. [For *Ammobaculites reophaciformis* Cushman, 1910, *U. S. Nat. Mus., Proc.*, vol. 38, p. 440, text figs. 12–14.]

——— *distans* Brady, 1879, var. *gracilis* Earland, **110,** 76, pl. 2, fig. 21. Recent, Antarctic, South Georgia.

——— *ouachitensis* Harlton, **159,** 9, pl. 1, fig. 5. Pennsylvanian, Oklahoma.

——— sp. Eichenberg, **113,** 3, pl. 3, fig. 2; pl. 1, fig. 2. Lower Cretaceous, Albian, Germany.

——— sp. Eichenberg, **114,** 169, pl. 17, fig. 4. Lower Cretaceous, Barremian, Germany,

——— *subfusiformis* Earland, **110,** 74, pl. 2. figs. 16–19. Recent, Antarctic, South Georgia. [For *R. scorpiurus* (pars) Goës, 1894, *K. Svensk. Vet. Akad. Handl.*, vol. 25, p. 25, pl. 6, figs. 166, 167.]

——— *subgoodlandensis* Vanderpool, **363,** 407, pl. 49, figs. 4–6. Lower Cretaceous, southern Oklahoma.

**Reussella** nov. gen. (nom. nov.), Galloway, **141,** 360. Fam. Buliminidae Jones, 1876. Genotype: *Verneuilina spinulosa* Reuss, 1850. Cretaceous to Recent. [New name for *Reussia* Schwager, 1877, on account of homonymy: *Reussia* McCoy, 1854.]

**Reussellinae** nov. subfam., Cushman, **74,** 223. Subfam. of Buliminidae Jones, 1876. Cretaceous to Recent.

*Reussia eocena* Cushman, **66,** 13, pl. 1, fig. 25. Upper Eocene, Ocala limestone, Florida. [Note: Should be named *Reussella eocena* (Cushman, 1933).]

*Rhabdammina trifurcata* Moreman, **246,** 394,

pl. 47, fig. 12. Upper Ordovician, Oklahoma.
**Rhynchogromiinae** nov. subfam., Galloway, **141,** 52. Subfam. of Lagynidae Schultze, 1854. Recent, shallow, cold marine water.
**Robulinae** nov. subfam., Galloway, **141,** 250. Subfam. of *Nodosariidae* Schultze, 1854. Jurassic to Recent.
*Robulus arcuato-striatus* (Hantken, 1875) var. *carolinianus* Cushman, **66,** 4, pl. 1, fig. 9. Upper Eocene, Ocala limestone, Alabama.
——— *gutticostatus* (Gümbel, 1868) var. *yazooensis* Cushman, **66,** 4, pl. 1, fig. 8. Upper Eocene, Alabama.
——— *nikobarensis* (Schwager, 1866) var. *warmani* Barbat and von Estorff, **15,** 168, pl. 23, fig. 12. Lower Miocene, California.
——— n. sp. Eichenberg, **113,** 14, pl. 8, fig. 7. Lower Cretaceous, Albian, Germany.
——— n. sp. Eichenberg, **114,** 172, pl. 17, fig. 12. Lower Cretaceous, Barremian, Germany.
——— sp. (n. sp.?) Eichenberg, **114,** 171, pl. 21, figs. 3, 5. Lower Cretaceous, Barremian, Germany.
——— n. sp.? aff. *Cristellaria rotulata* Brady, 1884 (non Lamarck, 1804), n. sp. aff. Thalmann, **345,** 253. Recent, West Indies.
*Robulus*, see also *Cristellaria*.
*Rotalia bassleri* Cushman and Cahill, **79,** 32, pl. 11, fig. 2. Miocene, Coastal Plain, U.S.A.
——— *cubana* Thalmann, **344,** 248, pl. 12, fig. 1. Recent, Cuba. [For *Calcarina pulchella* d'Orbigny, 1839.]
——— (?*Epistomina*) *polypioides* Eichenberg, **113,** 21, pl. 3, fig. 1. Lower Cretaceous, Albian, Germany.
——— *trispinosa* Thalmann, **344,** 249, pl. 12, figs. 2, 3. Recent, northern Java. [For *R. pulchella* auctorum non d'Orbigny, 1826.]
*Rupertia?floridana* Cushman, **66,** 21, pl. 2, figs. 13, 14. Upper Eocene, Ocala limestone, Florida.
**Rupertiinae** nov. subfam., Galloway, **141,** 302. Subfam. of Acervulinidae Schultze, 1854. Eocene to Recent.
**Ruttenia** nov. gen. (nom. nov.), Pijpers, **279,** 30. Fam. Anomalinidae Cushman, 1927. Upper Eocene, Bonaire. This new name substitutes Pijpers' genus *Bonairea*, with *Bonairea coronaeformis* Pijpers, 1933, as genotype.
**Rzehakininae** nov. subfam., Cushman, **74,** 144. Subfam. of *Silicinidae* Cushman, 1927. Upper Cretaceous?, lowest Eocene Europe, Recent, Antarctic.

*Saccammina biosculata* Moreman, **246,** 395, pl. 42, fig. 6. Middle Silurian, Oklahoma.
——— *flexiliramosa* Moreman, **246,** 397, pl. 42, fig. 13. Lower Mississippian, Oklahoma.
*Saracenaria arcuata* (d'Orbigny, 1846) var. *hantkeni* Cushman, **66,** 4, pl. 1, figs. 11, 12. Upper Eocene, South Carolina. [For *Cristellaria arcuata* Hantken, 1875, A magy. kir. földt, int. evkön., 4, p. 45, pl. 5, figs. 5, 6, non d'Orbigny, 1846.]
——— *italica* (Defrance, 1824) var. *crassicosta* Eichenberg, **113,** 17, pl. 5, fig. 2. Lower Cretaceous, Albian, Germany.
——— n. sp. Eichenberg, **113,** 16, pl. 7, fig. 9. Lower Cretaceous, Albian, Germany.
——— sp. Eichenberg, **114,** 173, pl. 21, fig. 4. Lower Cretaceous, Barremian, Germany.
——— sp. (? *S. italica* Defrance) Eichenberg, **114,** 174, pl. 20, fig. 9. Lower Cretaceous, Barremian, Germany.
——— ? sp. Cushman, **76,** 10, pl. 2, fig. 8. Recent, Tropical Pacific.
——— ? sp. Eichenberg, **113,** 17, pl. 8, fig. 6. Lower Cretaceous, Albian, Germany.
*Saracenaria*, see also *Cristellaria*.
**Semitextularia** nov. gen., Miller and Carmer, **242,** 428. Fam. Textulariidae d'Orbigny, 1846. Genotype: *S. thomasi* Miller and Carmer, 1933. Devonian, U. S. A.
——— *thomasi* Miller and Carmer, **242,** 429, pl. 50, fig. 10. Devonian, Iowa.
*Septammina bradyi* Cushman, **74,** 98, pl. 10, fig. 22, and Cushman, **75,** pl. 5, fig. 20. Pennsylvanian, England. No description given.
**Schackoina** nov. gen., Thalmann, 1932 (Subgenus), in Cushman, **74,** 267. Fam. Hantkeninidae Cushman. Upper Cretaceous. Erected by Thalmann as a subgenus of *Hantkenina*, this form has been given generic rank by Cushman.
*Siderolites heracleae* Arni, 1932, var. *pratigoviae* Arni, **13,** 12, pl. 1, figs. 1–6; pl. 2, figs. 7, 8; text figs. 5–7. (? Campanian-Maestrichtian, Switzerland.)
**Silicininae** nov. subfam., Earland, **110,** 89–91. Subfam. of Lituolidae Reuss, 1861. Upper Cretaceous, ? lower Eocene Europe, Recent.
**Silicininae** nov. subfam., Cushman, **74,** 143. Subfam. of Silicinidae Cushman, 1927. Jurassic. This new subfamily name is preoccupied by Earland, **110,** 89.
**Sinzowella** nov. gen., Cushman, **68,** 33. Fam. Trochamminidae Schwager, 1877. Genotype: *Nubecularia novorossica* Karrer and Sinzow, 1876, var. *deformis* Karrer and Sinzow, 1876. Miocene, Kishenew.
**Sphaerogypsina** nov. gen., Galloway, **141,** 309. Fam. Acervulinidae Schultze, 1854. Genotype: *Ceriopora globulus* Reuss, 1847. Eocene to Recent.
**Sphaeramminina** nov. subfam., Cushman, **74,** 87. Subfam. of Reophacidae Cushman, 1927. Recent.
**Sphaerulina** nov. gen., Lee, **216,** 16, 17. Fam. Fusulinidae Möller, 1878. Genotype: *S. crassispira* Lee, 1933. Lower Permian, China.
——— *crassispira* Lee, **216,** 17, pl. 1, figs. 2,

2*a*, 2*b*, 3*a*. Lower Permian, Kweichow, China.

*Spirillina arctica* Cushman, **77,** 6, pl. 2, figs. 1, 2. Recent, Arctic, Fox Basin.

——— *bendensis* Harlton, **159,** 9, pl. 2, fig. 3. Pennsylvanian, Oklahoma.

*Spiroloculina hadai* Thalmann, **345,** 354. Recent, Mutsu Bay, Japan. [For *S. costata* Hada, 1931, *Tôhôku Imp. Univ., Sci. Rept.*, (4), Biol., vol. 6, p. 84, text fig. 37, non Terquem, 1882.]

——— *robusta* Brady, 1884, var. *flinti* Lipparini, 1932, **222,** 59, pl. 4, fig. 3. Upper Miocene, Italy. [For *S. robusta* Brady, 1884, *Challenger Rep.*, p. 150, pl. 9, figs. 7, 8. Brady's species is the genotype for *Flintia*. Lipparini's variety, therefore, is a new variety of *Flintia robusta* (Brady, 1884).]

*Spiroplectammina rossae* Plummer, **281,** 66, pl. 5, figs. 1–3. Eocene, Midway formation, Texas.

*Spiroplectoides curta* Cushman, **66,** 11, pl. 1, fig. 24. Upper Eocene, South Carolina.

*Storthosphaera elongata* Cushman, 1918, var. *impudica* Earland, **110,** 56, pl. 1, figs. 23, 24. Recent, Antarctic, South Georgia.

**Terquemina** nov. gen., Galloway, **141,** 157. Fam. Endothyridae Rhumbler, 1895. Genoholotype: *T. devonica* Galloway, 1933. Middle Devonian, Germany.

——— *devonica* Galloway, **141,** 157, pl. 14, fig. 8. Middle Devonian Germany. [For Terquem, 1888, *Soc. Geol. France, Bull.*, (3), vol. 8, p. 414, pl. 11, fig. 10.]

**Tetrataxinae** nov. subfam., Galloway, **141,** 161. Fam. Endothyridae Rhumbler, 1895. Mississippian, Pennsylvanian and Permian.

**Tetrataxinae** nov. subfam., Cushman, **74,** 170. This subfamily of the *Trochamminidae* Schwager, 1877, is preoccupied by Galloway, 1933 (see above).

*Textularia martini* Pijpers, **278,** 57, text figs. 6–10. Upper Eocene, Bonaire.

——— *nitens* Earland, **110,** 98, pl. 3, figs. 31–35. Recent, Antarctic, South Georgia.

——— *smithvillensis* Cushman and Ellisor, **80,** 95, pl. 10, fig. 10. Eocene, Claiborne, Texas.

——— *tenuissima* Earland, **110,** 95, pl. 3, figs. 21–30. Recent, Antarctic, South Georgia. [For *T. elegans* Lacroix, 1932, *Inst. Oceanogr. Monaco, Bull.* 591, p. 8, figs. 4, 6 (non fig. 5).]

——— *wiesneri* Earland, **110,** 95, pl. 3, figs. 18–20. Recent, Antarctic, South Georgia. [For *T. parvula* Wiesner, 1931, *Foram. Deutsche Südpolar-Exped.*, p. 98, pl. 13, fig. 152, non Cushman, 1922.]

*Thurammina protea* Earland, **110,** 67, pl. 2, figs. 3–10. Recent, Antarctic, South Georgia.

*Triloculina tricostata* d'Orbigny, 1826, var. *fornasinii* Lipparini, **222,** 58, pl. 4, fig. 2. Upper Miocene, Italy.

*Trimosina orientalis* Cushman, **73,** 78, pl. 8, fig. 4. Recent, Tropical Pacific.

*Trisegmentina sidebottomi* Cushman, **74,** 165, pl. 15, fig. 24; and **75,** pl. 17, fig. 14. Recent, Mediterranean Sea. [For *Hauerina compressa* Sidebottom, 1904, *Manchester Lit. Phil. Soc., Mem. Proc.*, vol. 48, p. 19, pl. 5, figs. 7, 8, text fig. 8. non d'Orbigny, 1846.]

*Tritaxia schotborghi* Pijpers, **278,** 58, text figs. 22–26. Upper Eocene, Bonaire.

*Tritaxis haeusleri* Galloway, **141,** 212, pl. 19, fig. 2. Jurassic, Malm, Switzerland. [For: *Valvulina triangularis* Haeusler, 1890, *Abh. Schweiz. Pal. Ges.*, vol. 17, p. 75, pl. 12, figs. 23, 24, non d'Orbigny, 1826.]

*Trochammina bursaria* Chapman, **50,** 246, pl. 11, fig. 3. Silurian, Melbourne, Australia.

*Turritellella laevigata* Earland, **110,** 85, pl. 3, figs. 5–8. Recent, Antarctic, South Georgia. (See also **110,** 132.)

*Urnula arctica* Cushman, **77,** 1, pl. 1, figs. 1, 2. Recent, Arctic, northeastern Greenland.

*Urnulina rotundata* Cushman and Cahill, **79,** 6, pl. 1, fig. 4. Miocene, Coastal Plain, U. S. A.

*Uvigerina bonairensis* Pijpers, **278,** 69, text figs. 95, 96. Upper Eocene, Bonaire. [For *U. cocoaensis* Cushman and Applin, 1926, *Am. Assoc. Petroleum Geologists, Bull.*, vol. 10, p. 174, pl. 8, fig. 15, non Cushman, 1925.]

——— *gesteri* Barbat and von Estorff, **15,** 171, pl. 23, figs. 7, 18. Lower Miocene, California.

——— *glabrans* Cushman, **66,** 13, pl. 1, fig. 28. Upper Eocene, Alabama.

——— *kernensis* Barbat and von Estorff, **15,** 172, pl. 23, fig. 13. Lower Miocene, California.

——— *proboscidea* Schwager, 1866, var. *vadescens* Cushman, **73,** 85, pl. 8, figs. 14, 15. Recent, Tropical Pacific.

——— *tenuistriata* Reuss, 1870, var. *gaudryinoides* Lipparini, **222,** 65, pl. 6, figs. 7, 8. Upper Miocene, Italy.

——— *tenuistriata* Reuss, 1870, var. *siphogenerinoides* Lipparini, **222,** 64, pl. 6, figs. 2–6. Upper Miocene, Italy.

——— *westermanni* Pijpers, **278,** 69, text figs. 93, 94. Upper Eocene, Bonaire.

——— *yazooensis* Cushman, **66,** 13, pl. 1, fig. 29. Upper Eocene, Alabama.

*Vaginulina* sp. Eichenberg, **113,** 12, pl. 5, fig. 3. Lower Cretaceous, Albian, Germany.

——— sp. Eichenberg, **114,** 188, pl. 21, fig. 6. Lower Cretaceous, Barremian, Germany.

——— *stolleyi* Eichenberg, **113,** 11, pl. 2,

fig. 14. Lower Cretaceous, Albian, Germany.

**Valvulammina** nov. gen. Cushman, **68,** 37. Fam. Valvulinidae Cushman, 1927. Genotype: *Valvulina globulosa* d'Orbigny. Eocene, France. [Note: As far as I am aware there is no *V. globulosa* either described or figured by d'Orbigny. The genotype, most probably, is *V. globularis* d'Orbigny, 1826, non v. Münster, 1838.]

*Valvulineria jacksonensis* Cushman, **66,** 18, pl. 2, fig. 9. Upper Eocene, Ocala limestone, Alabama.

*Vanhoeffenella oculus* Earland, **110,** 54, pl. 1, fig. 22. Recent, Antarctic, South Georgia.

*Verneuilina cretosa* Cushman, **70,** 51, pl. 5, fig. 7. Upper Cretaceous, Texas.

**Victoriellidae** nov. fam., Cushman, **74,** 280. Tertiary to Recent.

*Virgulina navarroana* Cushman, **70,** 63, pl. 7, figs. 9, 10. Upper Cretaceous, Texas.

——— *recta* Cushman, **66,** 12, pl. 1, fig. 31. Upper Eocene, South Carolina. [For *Virgulina* sp. (?) Cushman, 1922, *U. S. Geol. Survey, Prof. Paper* 129-E, 92, pl. 16, figs. 2, 3.]

*Vulvulina molengraaffi* Pijpers, **278,** 57, text figs. 14–19. Upper Eocene, Bonaire.

*Webbinella limosa* Earland, **110,** 63, pl. 2, figs. 1, 2. Recent, Antarctic, South Georgia.

——— *quadripartita* Moreman, **246,** 396, pl. 47, figs. 4, 7. Lower Devonian, Oklahoma.

——— *tholus* Moreman, **246,** 395, pl. 47, figs. 8, 10. Upper Ordovician, Oklahoma.

**Wedekindellina** nov. gen. (nom. nov.), Dunbar and Henbest, in Dunbar, **108,** 134. Fam. Fusulinidae Möller, 1878. Genotype: *Fusulinella euthysepta* Henbest, 1928. Lower Pennsylvanian. [Note: This new name replaces *Wedekindella* Dunbar and Henbest, 1930, as well as *Wedekindia* Dunbar and Henbest, 1931, because they are preoccupied by Schindewolf for cephalopods.]

**Wiesnerella** nov. gen., Cushman, **68,** 33. Fam. Ophthalmidiidae Cushman, 1927. Genotype: *Planispirina auriculata* Egger, 1893, *Abh. k. Bayer. Akad. Wiss. München,* (2), vol. 17, pt. 2, p. 53, pl. 3, figs. 13–15. Recent.

**Yangchienia** nov. gen., Lee, **216,** 14. Fam. Fusulinidae Möller, 1878. Genotype: *Y. iniqua* Lee, 1933. Permian, China.

——— *iniqua,* Lee, **216,** 14, pl. 1, figs. 1, 1*a*. Lower Permian, Nanking, China.

## PALEONTOLOGICAL NOTES

# CAVELLINA NEBRASCENSIS (GEINITZ)

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ABSTRACT

The holotype, a hypotype, and a tracing made from the original figure of *Cavellina nebrascensis* (Geinitz) are here figured for the convenience of workers on ostracodes in the Mid-Continent region. A modern, as well as the original German description, are given.

Geinitz,[1] in his work on the Carboniferous and Permian of Nebraska, described one new ostracode which is of importance to workers on ostracodes in the Mid-Continent region. The types are deposited in the Museum of Comparative Zoölogy, Cambridge, Mass. Unfortunately, the holotype is a crushed form, and does not show the characteristics of the species as well as hypotypes from the same slab of rock. This species is common at Nebraska City, Nebraska, and is probably widespread throughout the Mid-Continent region.

[1] Geinitz, H. B., Carbonformation und Dyas in Nebraska: *Kais. Leopoldino-Carolinischen deut. Akad. Naturf.*, Verh., Bd. 33, Dresden, 1867.

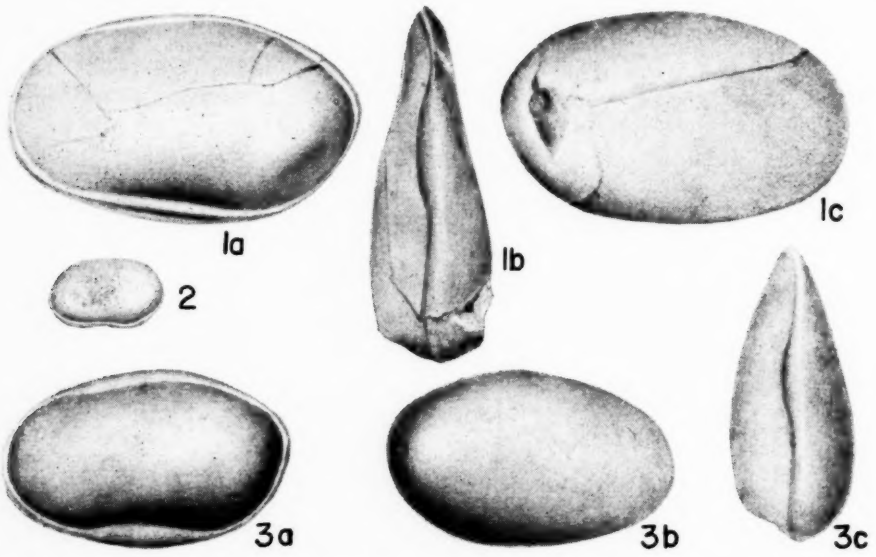
### Family CYTHERELLIDAE Sars

#### Genus CAVELLINA Coryell, 1928

CAVELLINA NEBRASCENSIS (Geinitz)

Text figures 1–3

*Cythere nebrascensis* GEINITZ, *1867*, Kais. Leopoldino-Carolinischen deut. Akad. Naturf., Verh., Bd. 33, p. 2, pl. 1, fig. 2.—MEEK, *1872*, U. S. Geol. Survey Terr., Final Rept. Nebraska, p. 237, pl. 11, figs. 33*a*, *b*.—KEYS, *1888*, Acad. Nat. Sci. Philadelphia, Proc., p. 243.—MILLER, *1889*




FIGS. 1–3—*Cavellina nebrascensis* (Geinitz). 1*a–c*, holotype, ×40; *a*, *c*, side views, *b*, dorsal view. 2, Tracing of original figure, ×17. 3*a–c*, Hypotype, ×34; *a*, *b*, side views, *c*, dorsal view. Figures drawn by Mrs. Lalicker.

North American Geology and Paleontology, p. 541.—WHITE, *1891*, U. S. Geol. Survey, Bull. 77, p. 30, pl. 4, fig. 2.—WELLER, *1898*, U. S. Geol. Survey, Bull. 153, p. 211.

*Cavellina nebrascensis* KELLETT, *1935*, Jour. Paleontology, vol. 9, no. 2, p. 146, pl. 18, fig. 1.

Carapace suboval in lateral view; greatest height slightly posterior to the center; dorsal border evenly convex; posterior end more sharply rounded than the anterior, slightly angled just above the median line; ventral border less convex than the dorsal and meeting the posterior end in a blunt angle; anterior end broadly rounded; dorsal and ventral overlaps of the right valve strong, most prominent dorsally slightly anterior to the center and ventrally at the center; surface smooth. Length of holotype, 1.16 mm.; height, 0.74 mm.; thickness, 0.40 mm. (crushed). Length of figured hypotype, 1.12 mm.; height, 0.75 mm.; thickness, 0.50 mm.

Holotype, Mus. Comp. Zoöl., 4418; figured hypotype, same, 4417.

Pennsylvanian, Wabaunsee group, west bluff of Missouri River, just above old steamboat landing and near the top, at Nebraska City, Nebraska.

The original description is as follows:

Die kleine, nur 1,12 mm. lange, elliptisch-bohnenförmige Schale ist fast doppelt so lang als hoch, gleichmässig gewölbt und mit einem schmalen Rande umgeben, glatt und glänzend. Ein kleiner Buckel liegt nahe dem vorderen Ende, an welchem die Schale sich abrundet und etwas verschmälert. Der Schlossrand ist gerade und erreicht nicht has hintere gleichfalls gerundete Ende. Der Unterrand ist sehr schwack gewölbt und verläuft regelmässig in die Seitenränder. Sie nähert sich, wie es scheint, sowohl der *C. recta* v. Keys. (in Schrenk's Reise II, 1854, p. 112, Taf. IV, F. 40) aus der permischen Formation Russlands als der *Cypris subrecta* Portlock (Rep. 1843, p. 316, Pl. XXIV, F. 13b) aus dem irischen Kohlenkalke.

Vorkommen: In den versteinerungsreichen Kalkplatten C. $c^{v}$. (Nr. 61) von Nebraska-City.

## RECOVERY OF FORAMINIFERA BY MEANS OF FLOTATION.

LABORATORY, N. V. DE BATAAFSCHE PETROLEUM MAATSCHAPPIJ

The Hague, Holland

The separation of foraminifera from rock samples meets with the difficulty that no general and at the same time quick and inexpensive method has been evolved that will yield satisfactory results in the majority of cases encountered. Handpicking with the aid of a binocular microscope, after washing the sample through a sieve in order to remove the clay-like material, gives excellent results. This method, however, is rather expensive in terms of time. Floating them with the aid of liquids of high specific gravity gives very good results when the foraminifera are filled with air, but cannot always be applied in other cases, such as when a part of them are filled with clay or pyrites. Another method for separating air-filled foraminifera consists of blowing the sample with a stream of air. Yet another method is to float off the foraminifera from the sample by means of "panning," whereby separation can be made as the heavier sand grains will, by this process, sink to the bottom of the dish.

A general method for the separation of foraminifera from clay and sand may be outlined as follows:

The foraminifera may be divided roughly into two groups: (1) The forms predominating in marine faunas composed of calcium carbonate. (2) The forms composed of organic material or of silicates or quartz, cemented together with silicates, calcium carbonate or other substances.

Both of these groups are most frequently embedded in a proportionately large mass of silicates and quartz present as clay and sand. The method of separation of calcium carbonate from silicates and quartz by means of flotation is generally known and might be applied to a mixture of foraminifera, clay, and

sand with a view to the possible separation of the calcareous forms. The mixture is stirred up in water until the material has been wholly disintegrated and a small amount of a phosphate buffering solution is added, if necessary, to adjust the PH up to 6.5. Then the addition of a small quantity of soap is required in order to produce a foam by passing a stream of air through the liquid. By this means the calcareous particles are carried to the top of the liquid and the foam removed. If more soap was used than strictly necessary, part of the clay will be floated also. Powdered marble, calcite, chemically precipitated calcium carbonate and even crushed calcareous foraminifera could be separated very well in this way, but it was found that unbroken foraminiferal shells did not come to the surface. This peculiarity could only be explained by supposing that the surface of these unbroken shells was not composed of calcium carbonate.

Only a few chemical analyses of foraminiferal shells are available in literature. One of the most complete is to be found in a paper by Clark and Wheeler, The inorganic constituents of marine invertebrates: *U. S. Geol. Survey, Prof. Paper* 124, 1933.

The analyses on page 2 of this paper show that only a small percentage of non-carbonate material is present; which, however, as the following experiment proved, constitutes the entire surface of the shell. Some foraminifera were placed in a well closed thick-walled glass tube filled to one-half with water saturated with carbon dioxide under a pressure of about twenty atmospheres. After two days standing at room temperature about 95 percent of the material of the shells was found to be dissolved but without destroying the superficial form of the foraminifera.

Thus it is seen that the surfaces of the shells under consideration are not composed of calcium carbonate but of siliceous material, such as the silicates of calcium and magnesium and, consequently, that it should not be possible to develop a general method for the separation of these silicates from the others, constituting the clay, by means of flotation. It is possible, however, to remove the clay by means of washing through sieves, as is in general use in paleontological laboratory practice, and, moreover. a method can be developed for the separation of the remaining coarser grains of siliceous nature; i.e., the foraminifera and perhaps other particles of similar properties from the generally much larger quantity of sand present by means of flotation. Gaudin, in his book Flotation (London, 1932) gives on pp. 358–386 a general outline for the separation of silicates from each other and from quartz, calcite and other carbonates, from which the following formula was derived:

Add a small amount of sodium silicate solution to the mixture of foraminifera, sand and coarse particles of silicates, which may be present, coal, etc., in order to depress the quartz. Stir a while, remove the silicate solution and add a soap solution. On blowing a stream of air through the liquid, the floatable particles will be seen gathering on the top of the liquid. They can easily be removed with the foam that has been formed.

Following this method it was found that some samples responded well, whereas others could not be separated. The former gave fair concentrates; the latter, however, showed the greater part of the quartz travelling upwards with the foraminifera. This was found to be due to the presence of a film of oily matter on the surfaces of both the sand grains and the foraminifera, probably originating from petroleum, as the samples had been obtained from oil fields. This film could be removed by washing the sieve residue with hot pyridine after which treatment the flotation process gave complete separation, e.g., nearly all the quartz was left at the bottom and practically all foraminifera could be gathered with the foam, appearing on top of the liquid. In general the concentrates were contaminated with some undesired grains of calcareous nature, crystal fragments of several silicates, particles of carbonaceous nature or organic structure, etc. The presence of this small number of undesirable grains is of relatively minor importance with respect to the concentration of the foraminifera which can be easily brought about.

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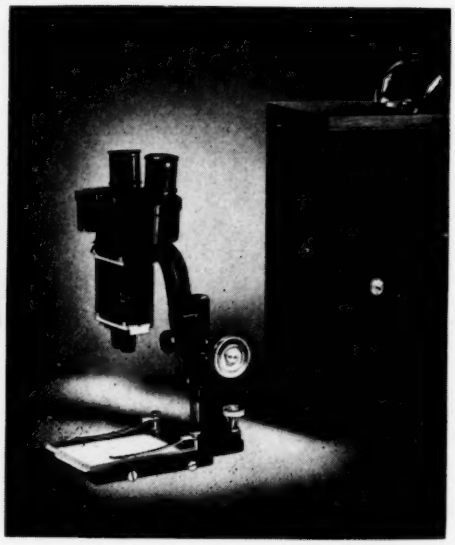

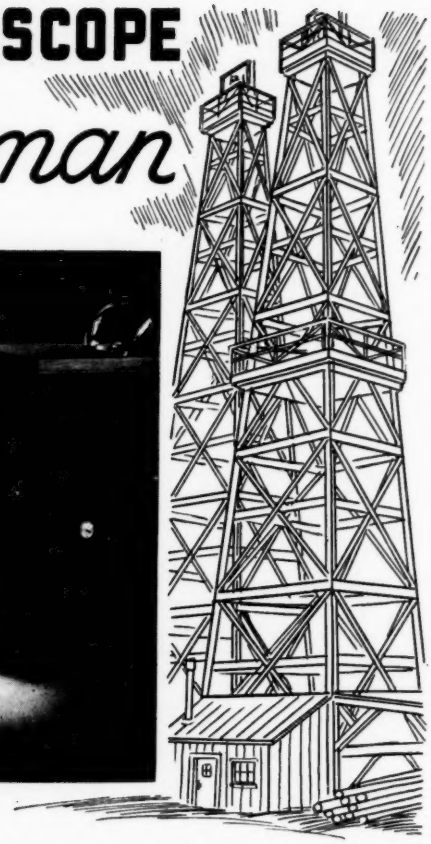

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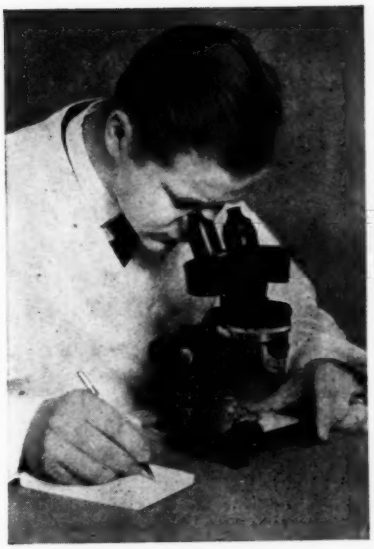

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